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ECOLOGY OF THE NEVADA TEST SITE:

AN ANNOTATED BIBLIOGRAPHY

WITH NARRATIVE SUMMARY,
KEYWORD INDEX,
AND SPECIES LISTS

December 2001

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ECOLOGY OF THE NEVADA TEST SITE: AN ANNOTATED BIBLIOGRAPHY

WITH NARRATIVE SUMMARY, KEYWORD INDEX, AND SPECIES LISTS

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ABSTRACT

This document contains an updated annotated bibliography of scientific publications and documents related to the ecology of the Nevada Test Site (NTS). It includes 333 annotated citations from the 1976 publication, *The Ecology of the Nevada Test Site: A Narrative Summary and Annotated Bibliography*, compiled by Thomas P. O'Farrell and LaVerne A. Emery. Another 532 citations have been added. Also included are lists of citations by research topics and updated lists of NTS flora and fauna.

The NTS is operated by the U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office. It occupies approximately 1,375 square miles (356,123 hectares) of desert and woodland terrain 70 miles (113 kilometers) northwest of Las Vegas, Nevada. It is geologically complex and has deposits of igneous, sedimentary, and metamorphic rocks spilling downslope from mountains and hills into several large basins. Except for widely scattered small springs and seeps, there is no permanent surface water. The climate exhibits extremes in temperature, precipitation, and wind velocity, as well as great variability in these parameters. At Yucca Flat, average daily maximum and minimum temperatures are 96 to 57°F (36 to 14°C) in July and 51 to 21°F (11 to -6°C) in January. Average annual precipitation ranges from about 5 to 13 inches (13 to 33 centimeters), increasing with increasing elevation, and is highly variable between sites and from year to year. Most soils have developed on alluvial deposits of mixed origins and characteristically have coarse texture, an accumulation of carbonates within a few feet of the surface, low organic matter content, and low carbon to nitrogen ratios. Moisture reserves of the soil profiles seldom exceed field moisture capacity except during the period of winter precipitation.

The site lies on the transition between the Mojave and Great Basin deserts; consequently, the flora and fauna consist of species characteristic of both deserts. A total of 752 taxa of vascular plants have been collected in ten major vegetation alliances. Twenty vegetation associations from among the alliances have been identified and mapped. Distributions of the Mojave Desert, Transition Zone, and Great Basin Desert vegetation alliances and associations are linked to temperature extremes, precipitation, and soil conditions. Twenty of the 30 natural water sources on the NTS have field indicators (hydrophytic vegetation, wetland hydrology, and hydric soils) that qualify them to be classified by the U.S. Army Corps of Engineers as jurisdictional wetlands and nine water sources may be classified as waters of the United States as regulated under the Clean Water Act of 1977.

At least 1,163 taxa of invertebrates within the phylum Arthropoda have been identified. Seventy-eight percent of the known arthropods are insects. Ants, termites, and ground-dwelling beetles are probably the most important groups of insects as regards distribution, abundance, and functional roles. Goldfish, golden shiners, and bluegills have been introduced on the NTS. The non-native bullfrog is the only amphibian that is known to occur on the NTS. The reptilian fauna includes 1 species of tortoise, 16 species of lizards, and 17 species of snakes. The most abundant, widely distributed lizards include the side-blotched lizard, western whiptail, desert horned toad, and desert spiny lizard. The western

shovel-nosed snake is the most common snake on the NTS, and there are four species of poisonous snakes. There are records of 239 species of birds observed on the NTS, approximately 80 percent of which are transients. A total of 44 terrestrial mammals and 15 species of bats have been recorded. Rodents account for half of the known species and are the most abundant and widespread group of mammals on the NTS. There is an apparent correlation between production by winter annual plants and reproduction in desert rodents on the NTS. Larger mammals on the site include: black-tailed jackrabbit, desert and Nuttall's cottontails, coyote, kit fox, badger, bobcat, and mountain lion. A herd of mule deer is located on the high mesas and surrounding bajadas. Small numbers of wild horses and pronghorn antelope range over small areas of the NTS. Bighorn sheep and burros are thought to be rare visitors. The desert tortoise (*Gopherus agassizii*) is the only resident species found on the NTS which is listed by the U.S. Fish and Wildlife Service as threatened. The bald eagle is a threatened bird which is a rare migrant on the site. No other threatened or endangered animal or plant is known to occur on the NTS.

ACKNOWLEDGMENTS

We are indebted to a number of individuals, agencies, and institutions for making possible the acquisition of Nevada Test Site (NTS) ecological research literature. Loretta J. Bush and Robert C. Wilson of Bechtel Nevada's (BN's) Administrative Resources Department spearheaded the effort to gather all needed publications. They conducted computer database searches, requested materials and loans from agency and university libraries, and tracked the progress of all requests. Their good humor and determination were invaluable. Jeff Gordon, BN librarian with the Coordination and Information Center (CIC), spent numerous hours searching the open literature via the computer database, DIALOG™ (Dialog Information Services, Inc.), and searching the government literature via the Office of Scientific and Technical Information to identify the appropriate documents and publications. We also wish to thank Martha DeMarre, manager of the CIC; Carol Crawford, Research Librarian with the Yucca Mountain Site Characterization Office Technical Information Center Library, Lynn Fenstemaker, Director of the Nevada Desert FACE (Free Air Carbon Dioxide Enrichment) Facility; and Anthony Hechanova, Research Scientist with the Harry Reid Center for Environmental Studies, University of Nevada, Las Vegas for providing assistance, some bibliographies to search, and/or copies of publication abstracts.

The following present and past NTS investigators graciously supplied information on publications and reprints of many articles: Phillip A. Medica, U.S. Fish and Wildlife Service; Robert S. Nowak, University of Nevada, Reno; Stanley. D. Smith, University of Nevada, Las Vegas; Kurt R. Rautenstrauch, Bechtel SAIC Corporation; Penny S. Amy, University of Nevada, Las Vegas; and Richard B. Hunter, Salisbury University, Salisbury, Maryland.

Several BN scientists provided updated material for the following narrative summary chapters or document sections: Stuart E. Rawlinson for Geology and Soils, Sigmund L. Drellack for Hydrology, Daniel G. Levitt for Climate, Dennis J. Hansen for Wetlands, and Derek B. Hall and Paul D. Greger for Fauna. Dennis J. Hansen assigned keywords to all abstracts, which was necessary to develop a topical index for the annotated bibliography. Ashley V. Housewright updated the flora and fauna species lists included in this document and created a computerized database to archive NTS historical species-specific collection and ecology information. Ashley also produced all of the maps presented in the narrative summary using the Geographic Information System software, ArcView® GIS. Jennifer L. Bishop scanned and proofed the abstracts of all post-1976 references which were gathered and added to this publication.

Robert C. Furlow of the U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office sponsored this project. His understanding of the ongoing value of this publication to NTS environmental managers and ecological researchers spawned the request and approved funding for this document.

We wish to thank Fina Martinez-Myers of the BN Administrative Resources Department who conducted the technical edit of this document under a very tight schedule. Her work and consistent, cooperative attitude were appreciated.

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ACRONYMS AND ABBREVIATIONS

ARL-SORD	Air Resources Laboratory, Special Operations and Research Division.
BN	Bechtel Nevada
cm	Centimeter(s)
DOE	U.S. Department of Energy
ELU	Ecological Landform Unit
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FACE	Free Air Carbon Dioxide Enrichment
ft	Foot/feet
ft^2	Square foot/feet
FWS	U.S. Fish and Wildlife Service
ha	Hectare(s)
IBP	International Biological Program
in	Inch
IT	International Technologies Corporation
kg/ha	Kilograms per hectare
km	Kilometer(s)
km^2	Square kilometer(s)
lb/ac	Pounds per acre
m	Meter(s)
m^2	Square meter(s)
mi	Mile(s)
mi^2	Square mile(s)
mm	Millimeter(s)
mph	Miles per hour
m/s	Meters per second
NAEG	Nevada Applied Ecology Group

NAFR	Nellis Air Force Range
NAPP	Net above-ground annual primary production
NNSA/NV	U.S. Department of Energy National Nuclear Security Administration Nevada Operations Office
NOAA	National Oceanic and Atmospheric Administration
NTS	Nevada Test Site
YMSCO	Yucca Mountain Site Characterization Office

INTRODUCTION

The U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Operations Office (NNSA/NV) has sponsored ecological and life science research and long-term ecological monitoring on the Nevada Test Site (NTS) for over 40 years. Prior to establishment of the NTS, there were no major scientific investigations in the immediate area, and little was known, even in descriptive terms, about the indigenous flora and fauna. Over the years, an important task of investigators has been to gather baseline information on the ecology of the NTS. Many of the programs in the 1960s through 1980s represented pioneering efforts to determine the fate and effects of radiation in the environment following both surface and underground nuclear detonations. Since studies required comparisons between disturbed and control sites, a wealth of information was needed on the basic structure and function of the desert ecosystem. Also, since passage of the National Environmental Policy Act of 1969, there was a need for a descriptive summary of the ecology of the NTS that would meet the needs of management personnel preparing Environmental Impact Statements for proposed and continuing on-site operations. In 1976, *The Ecology of the Nevada Test Site: A Narrative Summary and Annotated Bibliography* (O'Farrell and Emery, 1976) was published. This landmark document summarized all readily-available ecological publications and reports through 1975. Its stated goals were to (1) gather all relevant literature concerning the ecology of the NTS, (2) synthesize the essential elements necessary for understanding and describing the key biotic/abiotic interactions, (3) provide a referenced narrative summary of all gathered literature, and (4) collate the narrative summary and bibliography with sufficient supportive information so that site environmental management personnel could readily extract the necessary documentation to meet specific management goals. The 1976 publication provided a necessary focal point for collection and integration of NTS ecological information.

Over the past 25 years, the need has arisen to update the original annotated bibliography. Since 1976, there have been numerous ecological publications and work conducted on the NTS, much of which summarize work initiated as long ago as the late 1960s. Between 1967 and 1974, the United States and 57 other nations participated in an International Biological Program (IBP). The National Science Foundation administered the U.S. programs, and funded most of the research. However, the DOE made substantial funding contributions to IBP-oriented studies conducted on the NTS for the Desert Biome program within the IBP. O'Farrell and Emery (1976) included only a listing, without any annotation, of those IBP-Desert Biome Research Memoranda for studies conducted on the NTS. The Nevada Applied Ecology Group (NAEG) started research in the 1970s to address the transport, exposure, and impacts of radionuclides on NTS biota and ecosystems, and the research continued through the 1980s. Numerous NAEG-published bibliographies were produced periodically after 1976 to compile the resultant publications. Also, many new ecological monitoring and research efforts were started after 1976 to meet the goals of new DOE-sponsored programs. For example, data were gathered in the 1980s and 1990s to assess ecological impacts of the proposed high-level nuclear waste repository at Yucca Mountain in western Jackass Flats and to evaluate desert revegetation techniques used for the Yucca Mountain Site Characterization program. In the 1990s, data began to be collected to describe and model the impacts of elevated carbon dioxide levels on the Mojave Desert ecosystem.

The latter field experiments are presently conducted at the Nevada Desert FACE (Free Air Carbon Dioxide Enrichment) Facility in Frenchman Flat. This facility is a collaborative research operation between the University of Nevada, Las Vegas; University of Nevada, Reno; Desert Research Institute; DOE Brookhaven National Laboratory; and DOE NNSA/NV. The purpose of this report is to provide a document which compiles all current and historical ecological literature pertaining to the NTS. A secondary objective of this document is to provide a topical reference, by keywords, so that NNSA/NV environmental management personnel and ecology and life science researchers can readily extract the necessary documentation to meet specific management or research goals.

The computerized searches for new (post-1975) ecological documents and publications was performed using the following agency-sponsored and commercial databases: DOE's Office of Scientific and Technical Information database; the federal government's National Technical Information Service database; and the commercial database DIALOG™ (Dialog Information Services, Inc.), which contains over 12 terabytes of information (more than 6 billion pages with up to 4 records per page) including records from journals, conferences, reports, and other publications not catalogued elsewhere. Publications identified by the searches as applicable were gathered from the libraries of the following entities: University of Nevada, Reno; University of Nevada, Las Vegas; Los Alamos National Laboratory; Lawrence Livermore National Laboratory; and the DOE Yucca Mountain Site Characterization Office. The Online Computer Library Center was used by Bechtel Nevada (BN) librarians to locate and request copies of all publications not found within the state university or company/agency libraries listed above.

Database searches included various combinations of keyword roots. Keywords such as Nevada, test site, environmental, ecological, and others were used. Examples of roots for these words include nev., nv, enviro* (with an asterisk *, or other symbol, acting as a wild card giving all forms of the word after the root), and ecolo*. Hundreds of additional keywords were searched including author names, common and Latin derivatives of plant and animal names, and additional technical words found in on-hand copies of relevant scientific and technical publications. In most databases, we searched the full database. In DIALOG, under ALLSCIENCE, we searched its standard subcategories of Agriculture and Nutrition, Chemistry, Energy and Environment, Medicine and Biosciences, and Science and Technology.

We followed the same guidelines for references as did O'Farrell and Emery (1976). We tried to include only those sources of information that are readily available to most readers. We established an arbitrary ranking system of decreasing availability, and sought to use the document with the highest ranking: (1) scientific journal articles and books, available in all large libraries and also as reprints from authors; (2) internal topical reports, with limited distribution of hard copies; (3) prepublication series, with very restricted distribution and rapidly outdated by final publications; and (4) annual reports, with limited distribution of preliminary material, but often containing essential background information on projects not subsequently documented in another format.

There were many NAEG and U.S. Environmental Protection Agency-sponsored radionuclide studies conducted on the NTS whose references were not included in this update. These were papers which dealt solely with agricultural species (i.e., crops, cattle, sheep, etc.) and were, therefore, not germane to the ecology of native plants and animals. Also not included were radionuclide inventories in NTS soils and numerous articles on soil radionuclide resuspension and human pathway dose modeling. The reader is encouraged to reference the bibliographies of all NAEG publications to locate the full scope of radiological research conducted on the NTS. Some journal articles and book chapters written by past and present researchers on the NTS were excluded if they were summaries of NTS data cited elsewhere, or if the data were not specifically identified as being collected on the NTS. Also not included were NTS and Yucca Mountain annual site environmental reports. These reports summarize results of radiological and non-radiological monitoring and surveillance of the NTS and report all compliance activities related to environmental regulations germane to the NTS. Readers interested in annual radiological surveillance data for air, surface water, groundwater, and soil are encouraged to access these reports which are listed chronologically at the back of this document. Ecological monitoring of flora and fauna of the NTS may, in some years, be summarized in these documents, but the data are usually reported in more detail in other documents which have been included in the annotated bibliography.

All citations in the annotated bibliography are numbered and listed in alphabetical order by senior author, with a further breakdown according to the number and alphabetical ordering of the coauthors, and then by ascending chronological order within the multiple authorships. The annotations for the 333 citations included in O'Farrell and Emery (1976) were reproduced in this document with little or no editing. Those annotations were obtained from either the authors, abstracting services, or were written by O'Farrell and Emery themselves. Whenever they were known, initials of the abstractors follow their work. For this update, annotations were obtained from the abstract, executive summary, or introduction within each reference, and were reproduced in total or in part. This saved a tremendous amount of time in compiling the citations; however, the result is that there is little consistency across the added citations in regards to the thoroughness and format of the annotations. Also, as a result, some citation annotations contain references to other publications. No attempt was made to list those publications.

All citations, including the original 333 from O'Farrell and Emery (1976), were assigned keywords to generally define their topic. A computerized search was then conducted on the topical keywords to produce a keyword index for the annotated bibliography. This index will assist the reader in finding those annotations pertaining to each topic.

To save time and retain valuable summarizations of information, many portions of text found in O'Farrell and Emery (1976) were reproduced in this document. O'Farrell and Emery (1976) provided a valuable synthesis of the ecological information from their 333 original citations. Their summaries were updated in regards to the numbers of known taxa and current descriptions of vegetation associations and known animal distributions. Due to time constraints, no attempt was made to conduct a thorough review of all new citations from 1976 to the present nor to summarize the body of this ecological information. Most of the narrative summaries on the location, geology, hydrology, climatology, and soils of the NTS were rewritten by a number of specialists (see Acknowledgments). These chapters are not meant to be definitive, but to give the reader sufficient baselines concerning abiotic elements so that a better understanding of the biotic associations can be drawn. Appropriate references are listed in these chapters so the reader can obtain more detailed descriptions.

The annotated bibliography is followed by species lists of all the flora and fauna known to have been collected or observed on the NTS. Scientific names are included for all plants and animals following the most recent taxonomic conventions. The sources used for scientific and common names are listed. Except for important vertebrates, common names were used sparingly to avoid confusing the reader with colloquial names that are not necessarily accepted or even unique.

Except where noted, all photographs were taken for the NNSA/NV by BN ecologists or past NTS researches, or they were obtained from the NTS photographic archives maintained at BN's Remote Sensing Laboratory. The photographer's name, when known, is provided.

NARRATIVE SUMMARY

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LOCATION

The U.S. Department of Energy's (DOE's) Nevada Test Site (NTS) occupies 3,567 square kilometers (km^2) (1,375 square miles [mi^2]) of arid, basin and range terrain in Nye County in south-central Nevada (Figure 1). The site was established to permit testing of nuclear devices, both underground and in the atmosphere. A total of 100 atmospheric detonations was conducted before the Limited Test Ban Treaty was signed in August 1963. Approximately 800 underground nuclear tests have been conducted at the NTS. Sixteen of the atmospheric and 70 of the underground tests on the NTS were safety experiments, which by design produced little or no nuclear yield [762]. Las Vegas, located in Clark County, is 105 kilometers (km) (65 miles [mi]) southeast of the NTS and is the closest large city. Clark County has over 797, 000 inhabitants [762]. Nye County supports approximately 18,000 residents [762]. The NTS is buffered on all sides by federal lands (Figure 1). On the north and west, the NTS is bordered by the Nellis Air Force Range (NAFR) Complex; on the east, by a co-use area of the NAFR and the Desert National Wildlife Range; and on the south, by U.S. Bureau of Land Management lands.

The site consists of basically three large valleys, Yucca, Frenchman, and Jackass flats, that are bordered by mountains, ridges, and hills of variable, but relatively rugged relief (Figure 2). Frenchman and Yucca flats are closed basins with no outlets for surface runoff or gravitational flow of air at night. Each contains a large playa or dry lake bed (Figures 3-5). Jackass Flats, and its associated Fortymile Canyon drainage (Figure 6), has an outlet to the southwest at 819 meters (m) (2,688 feet [ft]), the lowest elevation on the NTS. The smaller basins, Mercury Valley, Rock Valley, Mid Valley, and Topopah Valley, which are subunits of major drainages, are also "open."

The northern and northwestern portions of the NTS are dominated by two high mesas, Rainier and Pahute, and the smaller Buckboard Mesa. The highest point on the NTS, 2,341 m (7,679 ft) in elevation, is on Rainier Mesa (Figure 7).

Figure 1. Location of the Nevada Test Site

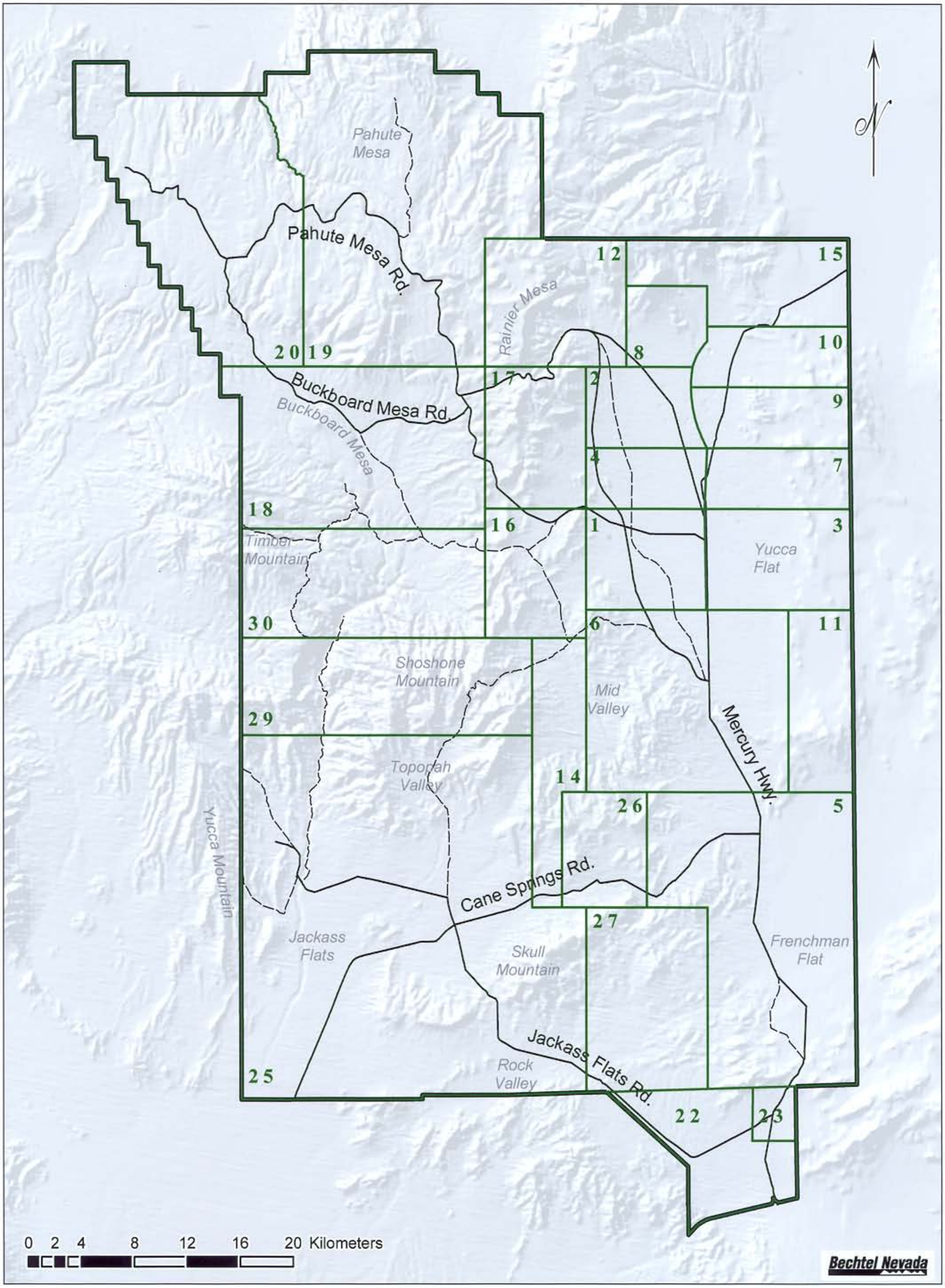

Figure 2. Major topographic features and administrative areas of the Nevada Test Site

Figure 3. View of Frenchman Flat showing surrounding mountainous terrain, alluvial deposits forming bajadas, the playa, and Mojave Desert vegetation after adequate winter rains have stimulated blooming of annual and perennial forbs.

Figure 4. View of Yucca Flat showing playa surrounded by rugged mountains and transitional vegetation types such as blackbrush (*Coleogyne ramosissima*) with an overstory of Joshua trees (*Yucca brevifolia*).

Figure 5. Aerial view of Yucca Flat showing subsidence craters formed during underground nuclear test shots, Yucca Lake playa, and the Spring Mountains in the background.

Figure 6. Aerial view of Fortymile Canyon

Figure 7. Aerial view of Rainier Mesa, the highest terrain on the Nevada Test Site.

GEOLOGY

Detailed investigations of the geology of the NTS have been in progress since 1951, shortly after the Test Site was established. The geologic studies were expanded in the 1950s and early 1960s as underground testing became the established mode for testing nuclear explosives. Since then, many regional and site studies have been conducted that have included detailed geologic mapping, sitewide geophysical surveys, exploratory drilling and testing, and detailed geotechnical studies. As a result of these many investigations, comprehensive databases are available on virtually every aspect of the geologic conditions on the NTS and surrounding areas [762].

If a sequence of rocks were stacked according to age at one location at the NTS, the sequence would be composed of Proterozoic and Paleozoic sedimentary rocks, intrusive Late Mesozoic granitic rocks, Miocene volcanic rocks, and post-volcanic sand and gravel. This sequence would be approximately 10,500 m (35,000 ft) thick (Frizzel and Shulters, 1990). Such a complete sequence of rocks, however, does not exist at the NTS because folding and faulting, intrusion, erosion, and depositional patterns have resulted in a complex surface geometry (Figure 8).

From Late Proterozoic to Middle Paleozoic (Early Devonian) time, a span of several hundred million years ending approximately 370 million years ago, western North America, including practically all of Nevada, was a stable continental margin where sedimentary rocks were deposited in both shallow-water and deep-water undersea troughs. Sediments deposited in the shallow-water trough consisted primarily of limestone, sandstone, and shale; whereas sediments deposited in the deep-water trough consisted primarily of submarine volcanic rocks, graywacke, shale, and chert. In Middle Paleozoic (Middle Devonian through Early Mississippian) time, approximately 370 to 330 million years ago, the stability of the western margin of North America ended in what is termed the Antler Orogeny, during which the deep-water sedimentary rocks were thrust eastward more than 100 km (63 mi) over the shallow-water sedimentary rocks (Fiero, 1986; Press and Siever, 1985).

The previous offshore geography of undersea troughs and deposition of sediments returned during Late Paleozoic through Middle Mesozoic time, only to be again disrupted in Late Mesozoic and Early Cenozoic (Early Tertiary) time during the Sevier and Laramide phases of the Cordilleran Orogeny, approximately 150 to 40 million years ago. As before, the deep-water sedimentary rocks were thrust eastward over the shallow-water sedimentary rocks; this time, beyond the previous limit. This episode of deformation resulted in the demise of the undersea troughs and generally, from west to east, large intrusions of molten rock and modification of existing older rocks through heat and pressure, east-directed folding and faulting of the Paleozoic rocks, block faulting and volcanism, and broad uplift of the North American continent (Press and Siever, 1985). The Climax Stock, an intrusion of granitic rock into older Paleozoic rocks in the northeastern part of the NTS, is the only Mesozoic-aged rock exposed on the NTS.

Terrain uplifted during Mesozoic and Early Tertiary time was eroded over a period of 25 million years until Oligocene time, about 40 million years ago. At this time and continuing until Early Miocene time, about 20 million years ago, the area which is now the Great Basin was subjected to

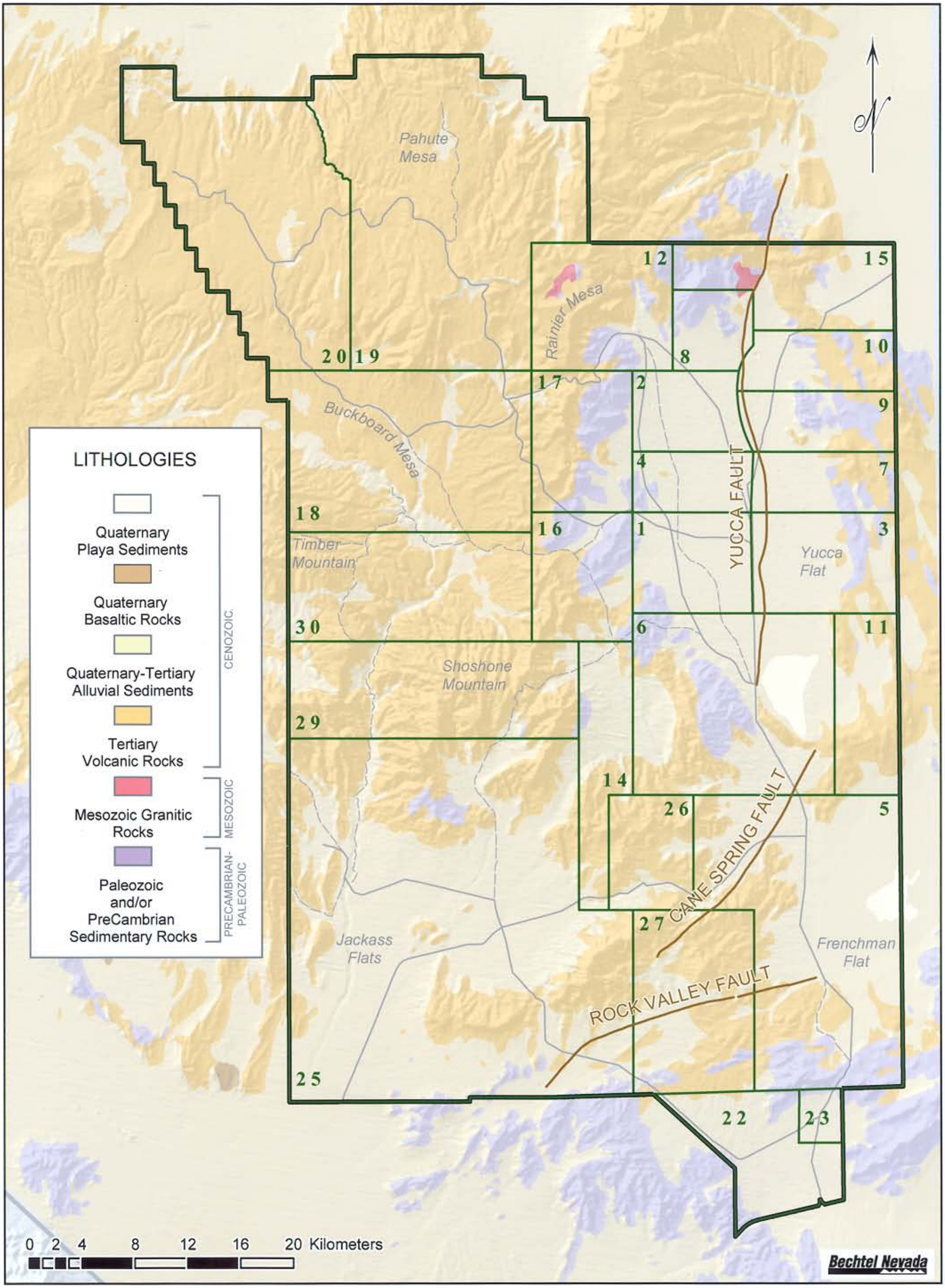

Figure 8. Generalized geology of the Nevada Test Site

intense volcanic eruptions that spread huge volumes of silica-rich ash over the terrain (Fiero, 1986). The welded ash composes parts of the mesas in the northeast part of the NTS, and in the recent past, provided an ideal medium for testing nuclear weapons.

In late Tertiary to Quaternary time, the Proterozoic and Paleozoic rocks and overlying Miocene-aged volcanic rocks began to arch upward. With this arching, came extension, or pulling apart, and thinning of the terrain over an area approximately 1,600 km (1,000 mi) long, north to south, and from 480 to 960 km (300 to 600 mi) wide, west to east (Fiero, 1986). Large blocks of terrain were either tilted or dropped down along faults that now define the boundaries between the roughly parallel valleys and mountains of the Basin and Range province of Nevada. The extensional faulting is thought to have occurred in two phases across the area of the NTS. The initial phase, about 16 to 14 million years ago, consisted of north-west- and north-east-trending normal faults; whereas the second phase, younger than 11 million years ago, consisted of north-to-south-trending normal faults (Cole et al., 1989).

Volcanic activity was coincident with the onset of extension. For the most part, the associated volcanic rocks are iron-rich andesite and basalt; however, in the vicinity of the NTS, an east-west band of silica-rich volcanic rocks forms what is termed the Southwestern Nevada Volcanic Field. These silica-rich rocks were erupted from a series of calderas present in the northwest part of the NTS, and form the greater part of Buckboard, Pahute, and Rainier Mesas in that area.

In contrast to the volcanic highlands that make up the northwest part of the NTS, valleys bounded by mountains composed of the Proterozoic and Paleozoic rocks and the Miocene volcanic rocks make up the other parts of the NTS. Yucca Flat, in the northeast part of the NTS, and Frenchman Flat in the southeast part of the NTS, are closed basins; that is, the mountains completely surround the flats. Both of these closed basins have a dry lake bed, or playa, in the lowest part of the basin. Jackass Flats, in the southwest part of the NTS, is open to the southwest and does not have a playa. Alluvium derived from erosion of the surrounding mountains is as thick as 1,200 m (3,940 ft) in these basins (Fiero, 1986).

HYDROLOGY

The hydrologic character of the NTS and vicinity reflects the region's arid climatic conditions and complex geology (D'Agnese et al., 1997). The hydrology of the NTS has been extensively studied for over 40 years [762], and numerous scientific reports and large databases are available. The following discussion of the hydrologic setting of the NTS is divided into summary descriptions of surface water and groundwater.

SURFACE WATER

The NTS is located within the Great Basin, a closed hydrographic province which comprises several closed hydrographic basins. The closed hydrographic basins of the NTS (most notably Yucca and Frenchman Flats) are subbasins of the Great Basin. Streams in the region are ephemeral, flowing only in response to precipitation events or snowmelt. Runoff is conveyed through normally dry washes toward the lowest areas of the closed hydrographic subbasins, and collects on playas. Two playas occur on the NTS: Frenchman Lake and Yucca Lake, which lie in Frenchman and Yucca Flats, respectively. While water may stand for a few weeks on the playas before evaporating, the playas are dry most of the year. Occasionally, migratory shorebirds have been observed if the playas have water on them during the spring or fall migratory season. Surface water may leave the NTS in only a few places, such as Fortymile Canyon in the southwest portion.

Springs that emanate from local perched groundwater systems are the only natural sources of perennial surface water in the region. There are 24 known springs or seeps on the NTS [281, 93] (Figure 9). Most springs are on the mesas and mountains in the northern part of the NTS, and there are no springs in the valley bottom areas. Spring discharge rates are low, ranging from 0.014 to 2.2 liters/second (0.22 to 35 gallons/minute) (International Technologies Corporation [IT], 1997). Most water discharged from springs travels only a short distance from the source before evaporating or infiltrating into the ground. Most of the springs and seeps, however, support wetland (hydrophytic) vegetation and 18 of them constitute natural wetlands as defined by the U.S. Army Corps of Engineers pursuant to Section 4.04 of the Clean Water Act (see Wetlands section of this report). The springs are important sources of water for wildlife, but they are too small to be of use as a public water supply source.

Other surface waters on the NTS include man-made impoundments constructed at several locations throughout the NTS to support various operations. These are numerous, and include open industrial reservoirs, containment ponds, and sewage lagoons. Many NTS animals including migratory waterfowl, wild horses, coyotes, and deer are common users of these man-made structures as sources of free water. Along with natural spring and seeps, these man-made sources can affect the movement patterns of some wildlife (e.g., wild horses).

GROUNDWATER

The NTS is located within the Death Valley regional groundwater flow system, one of the major hydrologic subdivisions of the southern Great Basin (Waddell et al., 1984; Laczniak et al., 1996). Groundwater in southern Nevada is conveyed within several flow-system subbasins within the Death Valley regional flow system (a subbasin is defined as the area that contributes water to a major surface discharge area [Laczniak et al., 1996]). Three principal groundwater subbasins, named for their down-gradient discharge areas, have been identified within the NTS region: the Ash Meadows, Oasis Valley, and Alkali Flat-Furnace Creek Ranch subbasins (Waddell et al., 1984) (Figure 10).

The groundwater-bearing rocks at the NTS have been classified into several hydrogeologic units, of which the most important is the lower carbonate aquifer, a thick sequence of Paleozoic carbonate rock. This unit extends throughout the subsurface of central and southeastern Nevada, and is considered to be a regional aquifer (Winograd and Thordarson, 1975; Laczniak et al., 1996; IT, 1996a). Various volcanic and alluvial aquifers are also locally important as water sources.

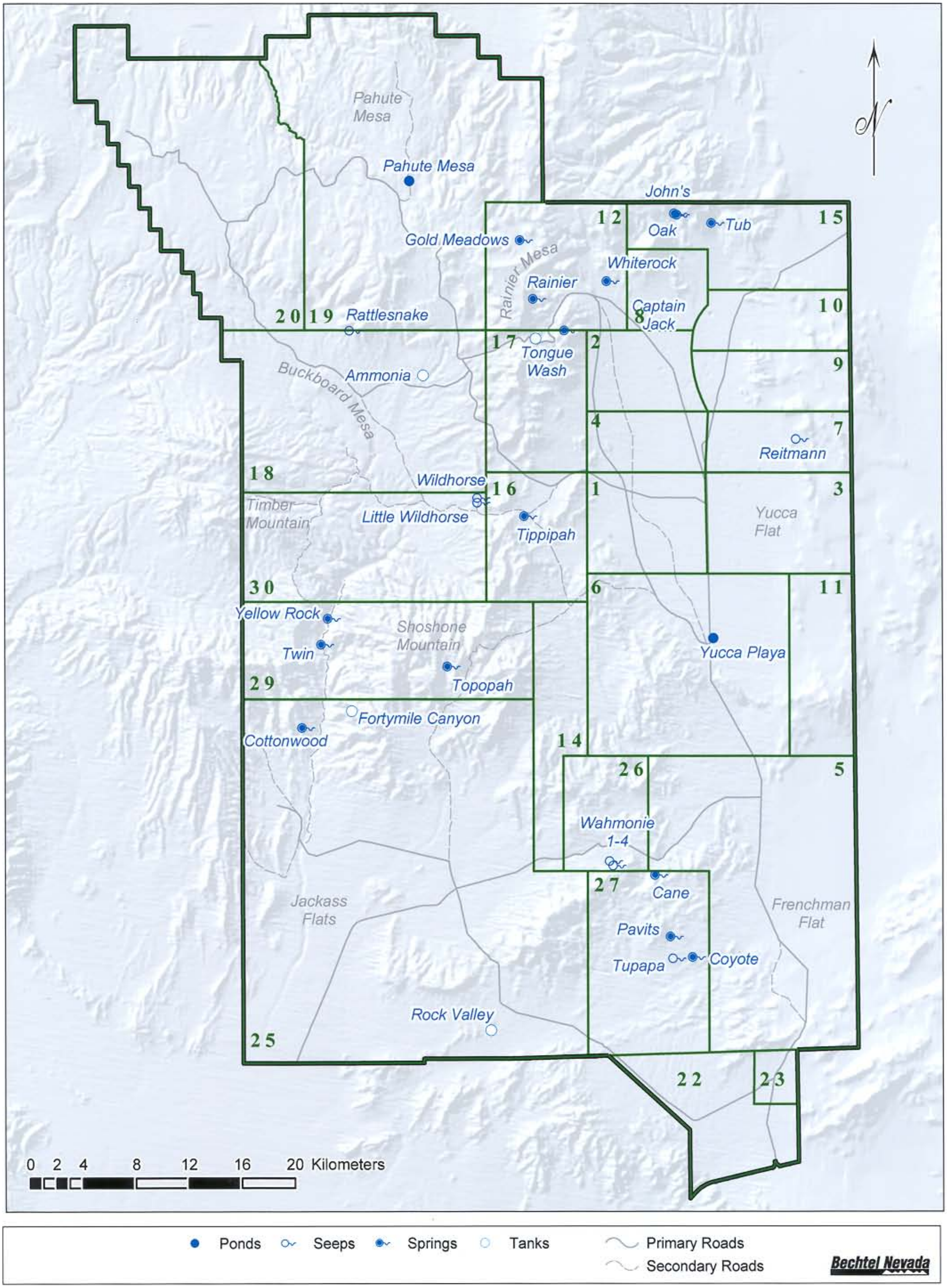

Figure 9. Natural water sources on the Nevada Test Site

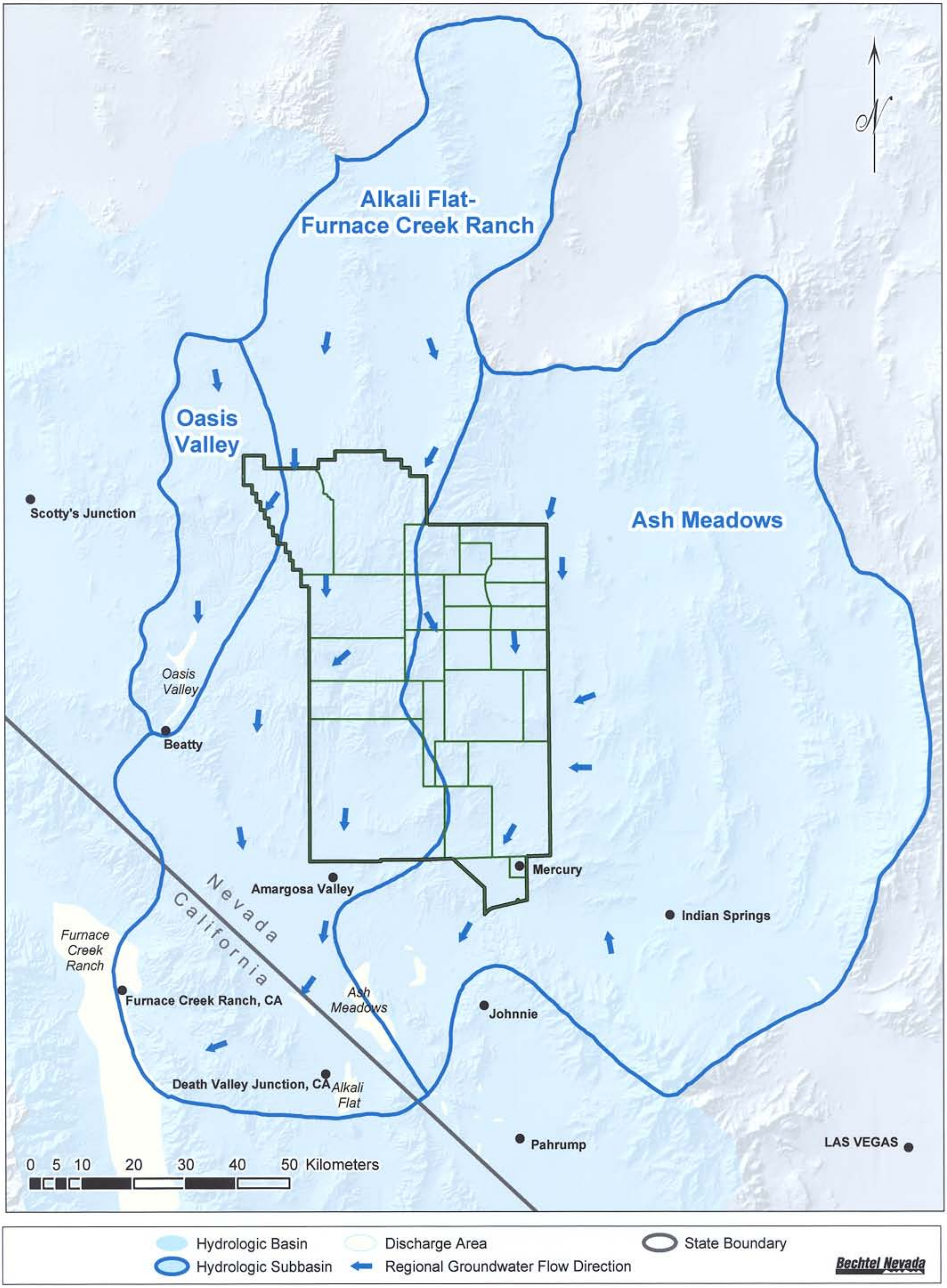

Figure 10. Groundwater subbasins of the Nevada Test Site

The depth to groundwater in wells at the NTS varies from about 210 m (690 ft) below the land surface under the Frenchman Flat playa in the southeastern NTS to more than 610 m (2,000 ft) below the land surface in the northwestern NTS, beneath Pahute Mesa (IT, 1996b; Reiner et al., 1995). Perched groundwater (isolated lenses of water lying above the regional groundwater level) occurs locally throughout the NTS, mainly within the volcanic rocks.

Recharge areas for the Death Valley groundwater system are the higher mountain ranges of central and southern Nevada, where there can be significant precipitation and snowmelt. Groundwater flow is generally from these upland areas to natural discharge areas in the south and southwest. Groundwater at the NTS is also derived from underflow from basins up-gradient of the area (Harrill et al., 1988). The direction of groundwater flow may locally be influenced by structure, rock type, or other geologic conditions. Based on existing water-level data [92] (Reiner et al., 1995; IT, 1996b) and flow models (IT, 1996a; D'Agnese et al., 1997), the general groundwater flow direction within major water-bearing units beneath the NTS is to the south and southwest (Figure 10).

Most of the natural discharge from the Death Valley flow system is via transpiration by plants or evaporation from soil and playas in the Amargosa Desert and Death Valley. Groundwater discharge at the NTS is minor, consisting of small springs which drain perched water lenses and artificial discharge at a limited number of water supply wells.

Groundwater is the only local source of potable water on the NTS. The 14 supply wells that make up the NTS water system produce water for human and industrial use from the carbonate, volcanic, and valley-fill aquifers. Water chemistry varies from a sodium-potassium-bicarbonate type to a calcium-magnesium-carbonate type, depending on the mineralogical composition of the aquifer source. Groundwater quality within aquifers of the NTS is generally acceptable for drinking water and industrial and agricultural uses (Chapman, 1994), and meets U.S. Environmental Protection Agency (EPA) drinking water standards [764] (Chapman and Lyles, 1993; Rose et al., 1997).

CLIMATE

The climate of the NTS is characterized by low precipitation, low humidity, and large diurnal temperature ranges. Variations in temperature and precipitation are generally correlated with elevation and latitude. The summers are generally hot, and the winters are mild. Average annual precipitation ranges from about 13 to 33 centimeters (cm) (5 to 13 inches [in]). Winds are generally out of the north in the winter months and from the south in the summer. Severe weather that may occur at the NTS includes thunderstorms, lightning, sandstorms, and, infrequently, tornadoes. Severe thunderstorms may cause flash flooding (DOE, 1986).

Climate has a strong influence on the ecology of the NTS. Frenchman Flat and Jackass Flat are two of the driest locations at the NTS. These valleys have vegetation typical of the Mojave desert. Further to the north, at higher elevation and latitude, is Yucca Flat, with slightly more precipitation and lower temperatures than at Frenchman Flat and Jackass Flat. Vegetation here is typical of the transitional zone between the Mojave and Great Basin deserts. The high mesas of the NTS have the greatest precipitation and lowest temperatures at the NTS. Vegetation here is typical of the Great Basin desert.

Annual precipitation at higher NTS elevations is about 23 cm (9 in), which includes snow accumulations. The lower elevations receive approximately 15 cm (6 in) of precipitation annually, with occasional snow accumulations usually lasting less than a day.

Winter precipitation, between October and April, results from storms coming in from the Pacific and accounts for about 65 percent of the average annual precipitation at the NTS. The NTS occupies a rain shadow position with respect to the Sierra Nevada mountain range to the west in which clouds carried by the prevailing winter west winds have lost much of their moisture as they drop down from the mountains. Winter rains from polar Pacific air moving in from the west are effectively blocked much of the time, so the continental polar air mass often dominates the climate in winter (Humphrey, 1962).

Precipitation in the summer usually falls in isolated showers, which cause large variations among local precipitation amounts. Summer precipitation occurs mainly in July and August when intense heating of the ground beneath moist air masses triggers thunderstorm development and associated lightning (DOE, 1995). Summer precipitation results mainly from either convection of moist air brought on southeasterly winds from the Gulf of Mexico, or from cyclonic lows developing over the Great Basin (Quiring, 1968). Occasionally summer storms move directly from the Gulf of California in a northeasterly direction, bringing widespread, heavy rains, known as monsoon rains. The driest months at the NTS are June and October (ARL-SORD, 2001).

Elevation strongly influences temperatures at the NTS. At an elevation of 2,000 m (6,560 ft) on Pahute Mesa, the average daily maximum and minimum temperatures are 4° C to -2° C (40° F to 28° F) in January and 27° C to 17° C (80° F to 62° F) in July. In Yucca Flat at an elevation of 1,195 m (3,920 ft), the average daily maximum and minimum temperatures are 11° C to -6° C (51° F to 21° F) in January, and 36° C to 14° C (96° F to 57° F) in July. Elevation at Mercury is 1,314 m (4,310 ft), and the extreme temperatures are 21° C to -11° C (69° F to 12° F) in January and 43° C to 15° C (109° F to 59° F) in July (DOE, 1995). The annual average temperature in the NTS area is 19° C (66° F) (NOAA, 1991). Monthly average temperatures range from 7° C (44° F) in January to 32° C (90° F) in July. Relative humidity readings (taken four times per day) range from 11 percent in June to 55 percent in January and December (DOE, 1995).

Average annual wind speeds and direction vary with location. At higher elevations on Pahute Mesa, the average annual wind speed is 4.4 meters/second (m/s) (10 miles per hour [mph]). The prevailing wind direction during the winter months is north-northeasterly, and during the summer months winds is southerly. In Yucca Flat, the average annual wind speed is 3 m/s (7 mph). The prevailing wind direction during the winter months is north-northwesterly, and during the summer months is south-southwesterly. At Mercury, the average annual wind speed is 3.6 m/s (8 mph), with northwesterly prevailing winds during the winter months, and southwesterly prevailing winds during the summer months. Wind speeds in excess of 27 m/s (60 mph), with gusts up to 48 m/s (107 mph), may be expected to occur once every 100 years (Quiring, 1968).

The predominant feature of the distributions of wind direction and speed at some point on the NTS is the contribution by the mountain-valley wind system. This system follows the sun and is, therefore, most intense in summer and least active in winter and on cloudy days. Heating during the day causes the air to move upslope, while cooling at night causes a gravity flow downslope, producing a pronounced daily cycle in the direction and speed of the wind, which is highly dependent on the orography (Quiring, 1968).

The driest and warmest portion of the NTS with a long-term weather data record is Well 5B, at an elevation of 939 m (3,080 ft), near the center of Frenchman Flat. The coldest and wettest area of the NTS with a long-term weather data record is A-12 station, at an elevation of 2,283 m (7,490 ft), on Rainier Mesa. Well 5B and A-12 stations are used to illustrate the range of climate at the NTS. Figures 11, 12, 13, and 14 illustrate the annual precipitation record, average monthly precipitation, average monthly air temperatures, and average monthly wind speeds at Frenchman Flat and Rainier Mesa weather stations, respectively.

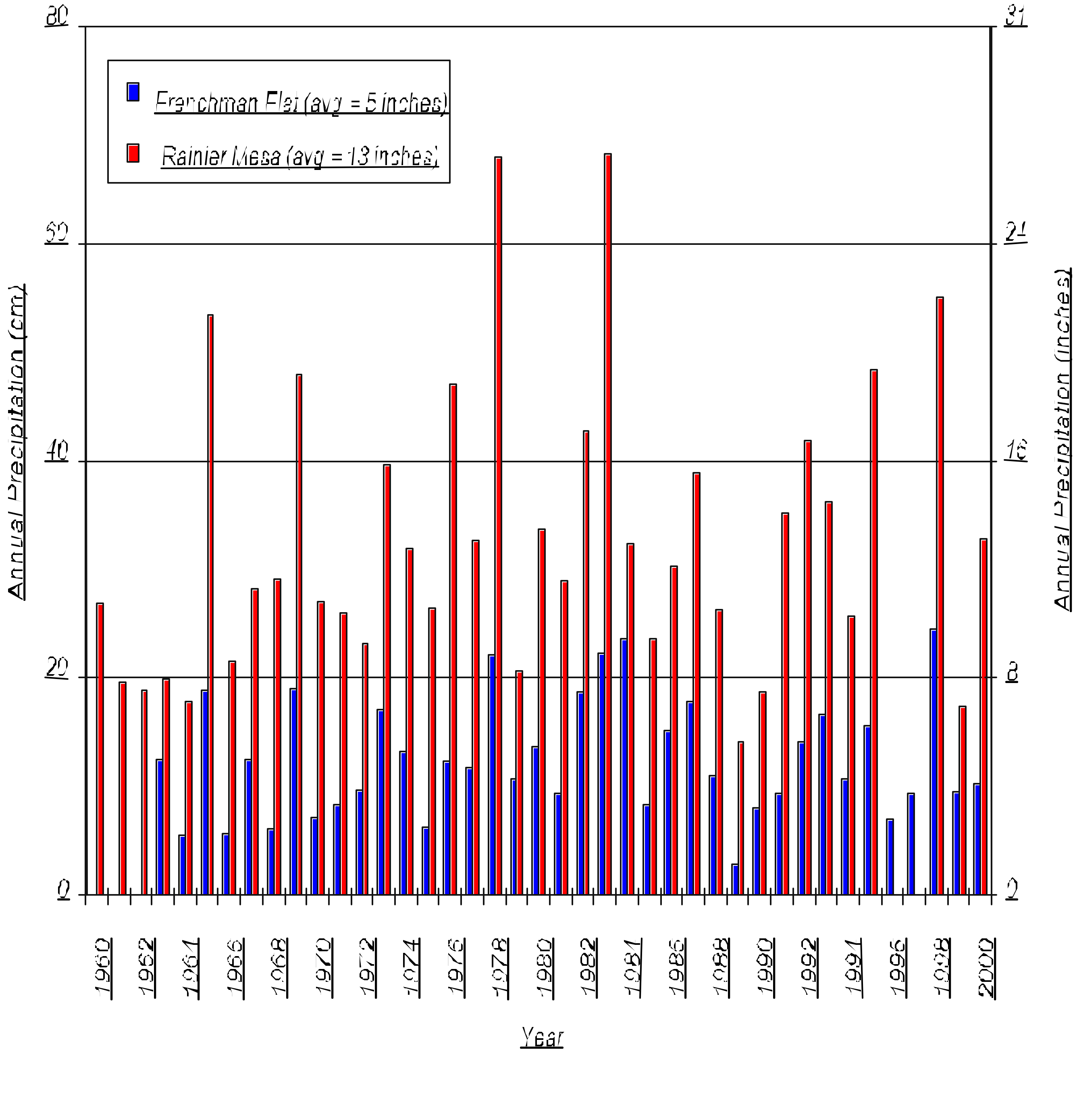

Figure 11. Annual precipitation totals at Frenchman Flat and Rainier Mesa weather stations. **(Note: Frenchman Flat station was not installed until 1963, and Rainier Mesa station was temporarily out of operation in 1996 and 1997).**

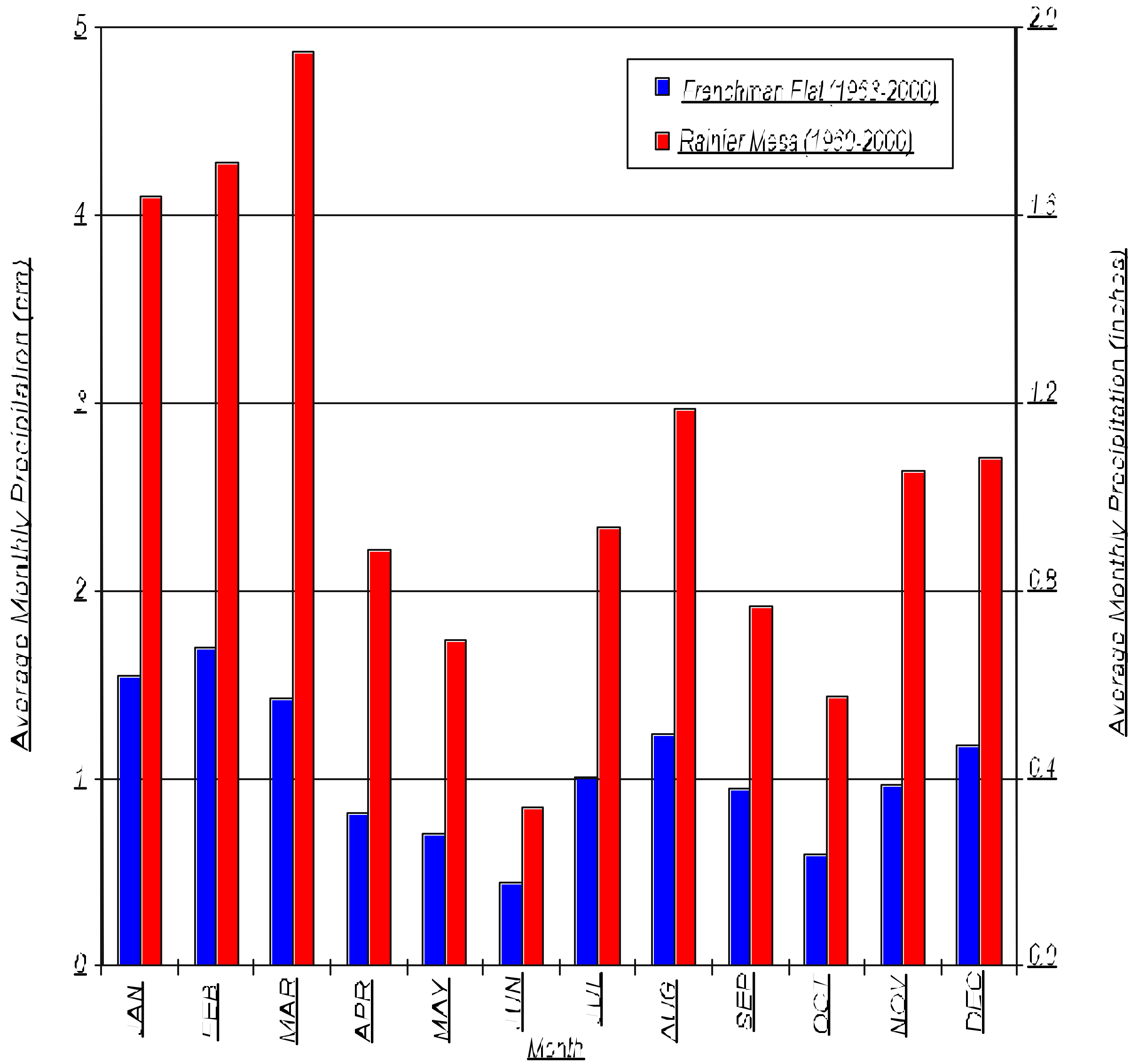

Figure 12. Average monthly precipitation totals at Frenchman Flat and Rainier Mesa weather stations

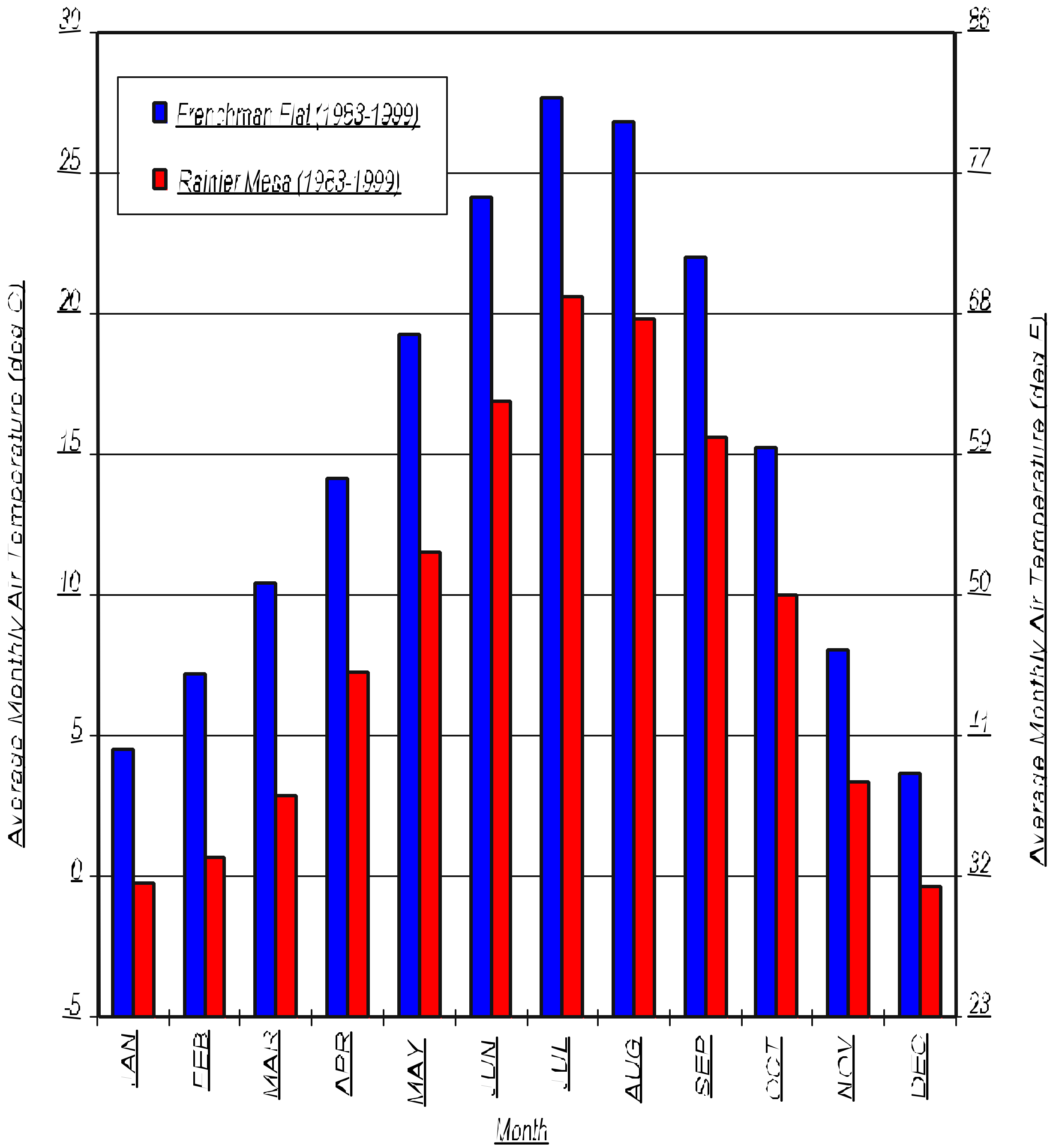

Figure 13. Average monthly air temperature at Frenchman Flat and Rainier Mesa weather stations

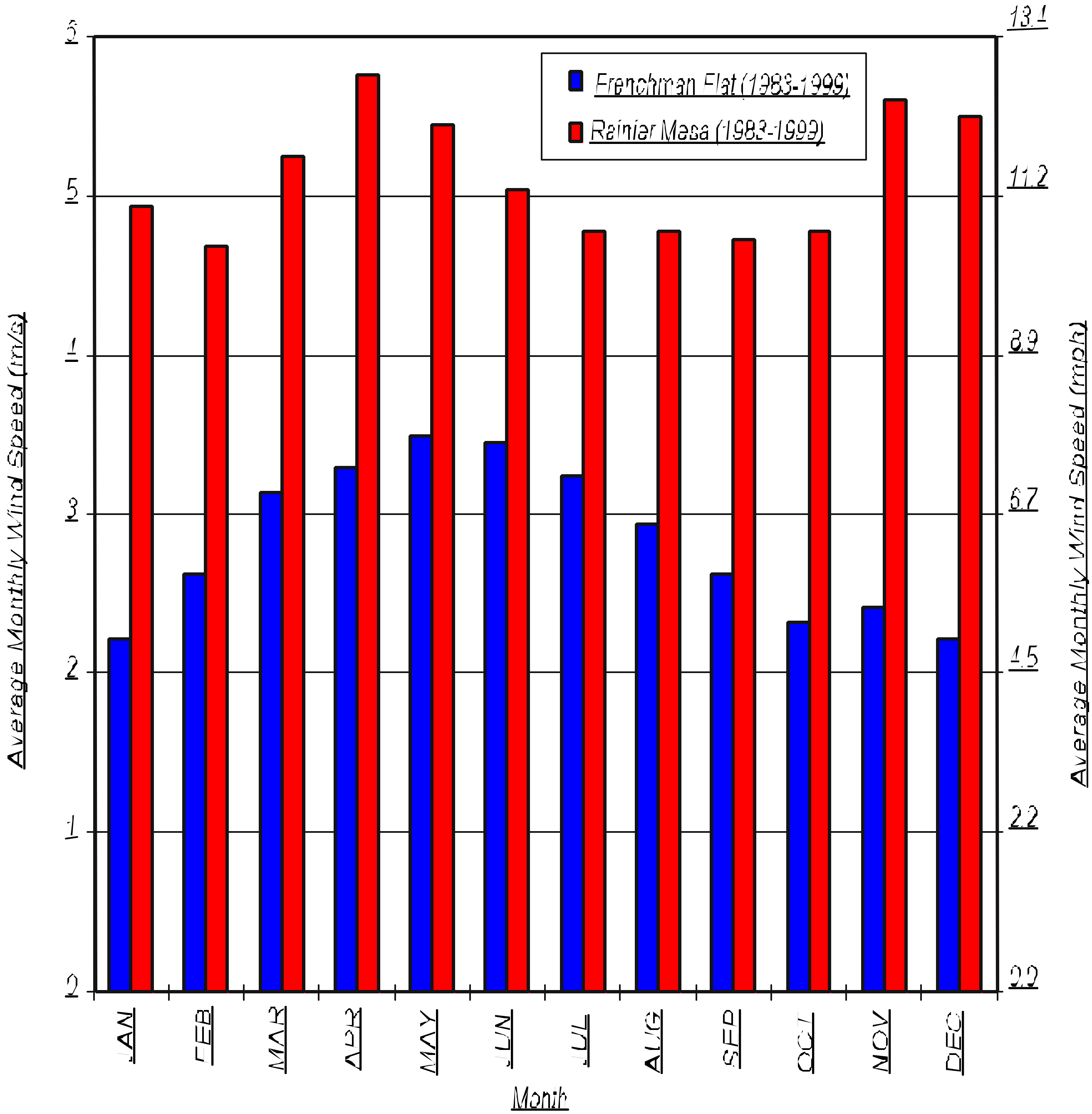

Figure 14. Average monthly wind speed at Frenchman Flat and Rainier Mesa weather stations

SOILS

There has not been a definitive soil survey of the NTS. Most of the data have been gathered at widely separated areas of local interest and to answer specific programmatic needs. These areas include the historic EPA farm in Area 15, a large portion of Area 18 that was used for cattle grazing, numerous sites contaminated by plutonium, sites where ecological vegetation studies have been conducted, the vicinity of Yucca Mountain where a high-level nuclear waste repository is being investigated, and at specific facilities where large buildings and waste disposal sites are located.

The following summary is reproduced in large part from O'Farrell and Emery [498]. It is, therefore, a synthesis of NTS soil data gathered only through 1975. Soil data published or compiled in documents after 1975 were not included in this document unless they contained biological/ ecological data as well. Also, no attempt was made to summarize in this narrative the post-1975 information on soils included in the annotated references of this document. The reader is encouraged to use the keyword index to identify all soil-related publications which are not referenced or summarized in the following paragraphs.

Most of the soils on the NTS have developed on alluvial deposits that contain unconsolidated parent materials of both sedimentary and volcanic origins. They have developed under conditions of high temperatures and low rainfall, and display characteristics of desert soils: coarse texture, an accumulation of carbonates within a few feet of the surface contributing to the formation of a caliche layer, low organic matter content, and low carbon/nitrogen ratios. Most of the soils can be classified as belonging to the Thermic Families [620], with those at higher elevations fitting into the Mesic Family classification [398].

The soils are young as regards profile development and show little evidence of leached upper horizons. Much of the diversity in soil profiles reflects their mixed alluvial origin. Coarser fragments are found in soils developed nearer the base of mountains and hills, and finer textures are found towards the middle of valleys. If clay is present, it is usually found in B horizons in more level areas [620].

Carbonate contents of soils can also be closely correlated with the origin of parent material, and it is highest in areas immediately adjacent to limestone mountain ranges. High carbonate concentrations are almost always correlated with the presence of a restrictive hardpan, usually at depths of 30 to 70 cm. Soils low in carbonate are most often those that have developed on alluvium of mixed igneous and sedimentary rocks [620].

The particle-size distribution of the soils also reflects formation on alluvial deposits. Variations in texture are largely due to differences in distributions of sand and silt particle-size fractions. At low elevations, there is characteristically a low clay content, but increased clay concentrations have been found on alluvial sediments in closed drainage basins such as Frenchman Flat. Soils at higher elevations may have clay contents of as much as 50 percent [398], although this is uncommon. The ratio of cation exchange capacity to percent clay is usually within 2 to 5, and occasionally can be greater than 10. In addition, the high soluble and exchangeable potassium content of some soils also indicates amorphous clays. Loess, consisting of variable-sized sandy material, blankets a major portion of the study areas.

Much of it probably originated from volcanic ash falls that have been further eroded, mixed, and transported by the wind [620].

Moisture retention characteristics of NTS soils are very poor and primarily reflect the low silt and clay content, as well as the relative lack of organic matter. Moisture reserves of the soil profiles seldom exceed field moisture capacity except during the period of winter precipitation. Vegetative growth and rising spring temperatures rapidly deplete soil water, and for 6 to 8 months soil moisture potential is below -30 bars, and it often falls below -90 bars in summer [620].

The soils are usually nonsaline-nonalkali (electrical conductivity less than 4 millimhos per cm; exchangeable sodium percentage less than 15) in profiles within root zones of perennial vegetation, except for a few sites within closed basins. Saline conditions have been found in deeper horizons in Rock Valley and Jackass Flats, but most occur around playas in closed basins. The highest levels of soluble salts have been found in deeper soil horizons on Frenchman Flat. Soluble sulphates are low in all profiles. The percent of free lime present is related primarily to contributions of limestone parent material to alluvium. Levels of micro-nutrients such as manganese, iron, copper, and zinc are low and variable between sites. The shrubs show no obvious signs of micronutrient deficiencies, and there is evidence that cycling of micronutrients takes place [620].

Cation exchange capacities vary considerably between areas and sharply reflect particle-size distributions of the soils. In Mercury Valley, Rock Valley, and Yucca Flat, soils are low in exchangeable sodium and high in calcium and magnesium, while sandy soils from Jackass Flats are low in calcium, magnesium, and sodium. Soils from Frenchman Flat have the highest cation exchange capacity and exchangeable potassium; potassium concentrations sometimes exceed the exchangeable calcium and magnesium content [620].

There is clear evidence of accelerated soil-forming processes under desert shrubs, which demonstrates an important role of shrubs in desert ecosystems. One of the most consistent characteristics of NTS soils is that the highest concentrations of organic carbon, organic nitrogen [484], and available phosphorus occur in the upper horizons under shrubs [620]. Shrubs intercept the wind-borne, finely textured loess, adding it to the coarser alluvial material at their bases. Salts also accumulate under shrubs, probably because of recycling through leaf-fall and litter decomposition, as well as trapping of airborne materials. Under shrubs, there is often some decomposition of subsurface hardpans, and a better developed A horizon. Below the A horizon, arbon/nitrogen ratios are around 10; in the A horizon they range from 5 to 30, although most are between 12 to 15. The A horizon is the only horizon in which the organic carbon content exceeds 1 percent. Low carbon to nitrogen ratios could be due to reduced organic matter content of desert soils, an increase in nitrogen fixation, or a combination of both [620]. In addition to the above, soil pH tends to be lower [239], conductivity of saturation extracts is higher, nitrates and chlorides accumulate more, and exchangeable cations, such as potassium [484], are greater under shrubs [620].

Species of algae and fungi grow on and in the soils [172, 173], contributing to soil stabilization. The algae are often enclosed in a colloidal sheath which binds particles of soil in a web-like matrix consolidating a surface crust [173, 642]. The water-holding capacity of the sheath improves moisture relations in the felted crusts. Data suggest that the algal crust in arid soils is an important link in the soil nitrogen cycle.

WETLANDS

Important biological communities on the NTS are those associated with springs or other natural sources of water. They are rare, localized habitats that are important to regional wildlife and to isolated populations of water-tolerant plants and aquatic organisms. From 1996 to 1999, natural water sources on the NTS were surveyed. The primary goal of the surveys was to identify those which might be considered jurisdictional wetlands that fall under the regulatory authority of the Clean Water Act of 1977 and which might be protected as rare habitats. Results of the initial wetland assessment, which included 25 sites, were published in 1997 [281]. Five additional wetlands were identified and described in 1998 and 1999 [93, 94].

The 30 natural water sources which have been surveyed and assessed include 15 springs, 9 seeps, 4 tank sites (natural rock depressions that catch and hold surface runoff), and 2 ephemeral ponds (Figure 9). Twenty of these were found to have field indicators (hydrophytic vegetation, wetland hydrology, and hydric soils) that qualify them to be classified by the U.S. Army Corps of Engineers as jurisdictional wetlands (Table 1). Ten water sources (four cave pools, four rock depressions, and two ponds) had unvegetated pools of water which did not meet the criteria for jurisdictional wetlands (Table 1), but which may be classified as waters of the United States based on the longevity of water at the sites through the year. They include: cave pools at four spring sites (Cane, Tippipah, Tub, and Whiterock springs), natural rock depression pools at four sites (Ammonia Tanks, Fortymile Canyon Tanks, Rock Valley Tank, and Tongue Wash Tank), and two ephemeral ponds (Pahute Mesa Pond and Yucca Playa Pond).

Eleven of the springs and seeps surveyed have surface flow of water all year long. These sites are Cane Spring, Captain Jack Spring, Cottonwood Spring, John's Spring, Oak Spring, Reitmann Seep, Tippipah Spring, Topopah Spring, Tub Spring, Twin Spring, and Whiterock Spring (Figure 15). The remaining sites are ephemeral; they may dry up at some period of time during the year or during dry years. The sizes of the NTS wetlands are very small. With the exception of Tippipah Spring, Pahute Mesa Pond, Whiterock Spring, and Yucca Playa Pond, most were less than 300 square meters (m^2) (3,228 square feet [ft^2]). They varied in size from less than 1 m^2 (10.8 ft^2) at Reitmann Seep to approximately 3,400 m^2 (37,000 ft^2) along the edges of Yucca Playa Pond, based on the area of hydrophytic vegetation. Water levels were generally shallow at all study sites, ranging from 3 to 200 cm (1.2 to 78.7 in). Flow rates of NTS springs measured during 1996 were very low, ranging from 0.0-3.0 liters/minute (ℓ/min) (0.0 to 0.80 gallons [gal/min]).

Eighty-one species of vascular plants have been recorded in or near the NTS wetland sites. Most of the species are forbs (33 species, 41 percent) followed by grasses, rushes, and sedges combined

Table 1. Hydrology and jurisdictional status of NTS natural water sources surveyed through December 1999.

Water Source	Area of Wetland Vegetation (m²)[a]	Area of Surface Water (m²)[b]	Flow Rate (ℓ/min)[c]	Maximum Depth[d] (cm)	Wetland Indicators: Vegetation	Wetland Indicators: Hydrology	Wetland Indicators: Soils	Jurisdictional Status[e]
Ammonia Tanks	0	30	0	100	no	yes	yes	no
Cane Spring	230	4	3.0	200	yes	yes	yes	yes
Captain Jack Spring	30	7	0.9	18	yes	yes	yes	yes
Cottonwood Spring	130	90	1.0	25	yes	yes	yes	yes
Coyote Spring	160	0	0	0	yes	yes	yes	yes
Fortymile Canyon Tanks	0	8	0.2	20	no	yes	yes	no
Gold Meadows Spring	45	0	0	0	yes	yes	yes	yes
John's Spring	50	5	0.4	3	yes	yes	yes	yes
Little Wildhorse Seep	30	2	0.3	40	yes	yes	yes	yes
Oak Spring	40	1	0.4	3	yes	yes	yes	yes
Pahute Mesa Pond	420	2,275	NM	30	yes	yes	yes	yes
Pavits Spring	0	0	0	0	no	yes	no	no
Rainier Spring	0	0	0	0	no	no	no	no
Rattlesnake Seep	50	25	<1	5	no	yes	yes	no
Reitmann Seep	1	1.5	0.2	15	yes	yes	yes	yes
Rock Valley Tank	0	0.1	0.	30	no	yes	no	no
Tippipah Spring	500	190	2.7	38	yes	yes	yes	yes
Tongue Wash Tank	0	4.5	0	25	no	yes	no	no
Topopah Spring	200	8	0.12	25	yes	yes	yes	yes
Tub Spring	0	0.1	0.1	5	no	yes	yes	no
Tupapa Seep	0	0	0	0	no	no	no	no
Twin Spring	27	2	NM	10	yes	yes	yes	yes
Wahmonie Seep 1	250	5	NM	8	yes	yes	yes	yes
Wahmonie Seep 2	150	0.25	0	0	yes	yes	yes	yes
Wahmonie Seep 3	180	0	0	0	yes	yes	yes	yes
Wahmonie Seep 4	250	1	NM	10	yes	yes	yes	yes
Whiterock Spring	1,800	0.1	1.9	3	yes	yes	yes	yes
Wildhorse Seep	150	2	<.1	50	yes	yes	yes	yes
Yellow Rock Spring	0	30	NM	40	no	yes	yes	no
Yucca Playa Pond	3,400[f]	22,930	0	150	yes	yes	yes	yes
Total Area (m²)	**8,093**	**25,622**						

[a]Total surface area over which wetland plans were located. [b]Maximum inundated area recorded at the time of the survey. [c]Maximum flow rate recorded during the year 1996. NM = flow observed but not measured. [d]Maximum depth of natural surface water pools. [e]Determination of jurisdictional wetland status based on presence of wetland indicators. [f]Area includes that defined by tree canopy cover and an equal area of extended roots.

Figure 15. Wash channel of Whiterock Spring in northern Yucca Flat. *Salix exigua* (sandbar willow) is one of three mesic plant species present. The spring qualifies as a jurisdictional wetland protected under the Clean Water Act and is the second largest wetland on the Nevada Test Site. (Photo by Dennis Hansen)

(30 species, 37 percent), and trees and shrubs combined (18 species, 22 percent). This is very different from the general flora of the NTS where forbs make up approximately 74 percent of the total number of species; grasses, rushes, and sedges make up only 12 percent; and trees and shrubs make up 14 percent [86, 507]. No plant species listed as threatened or endangered under the Endangered Species Act occur at any of the NTS natural water sources.

A total of 138 species of animals has been documented at NTS wetland sites, including various classes of animals such as mammals, birds, reptiles, and terrestrial insects. The largest group of vertebrates using NTS wetlands is birds (100 species). Passerine birds comprise the majority of birds recorded (80 species). Waterfowl use of NTS springs is negligible, probably due to the small surface areas of open water. Cane Spring and Yucca Playa Pond are the only natural NTS wetland sites that are known to attract migratory waterfowl. Many freshwater invertebrates occur in NTS natural water sources. They include nonparasitic nematodes (roundworms), oligochaetes (segmented worms), crustaceans (fairy shrimp, tadpole shrimp, clam shrimp, seed shrimp, copepods, water fleas), hydrobiid gastropods (springsnails), and chironomids (midge larvae). Use of wetland habitats on the NTS by federally listed threatened or endangered animals is negligible. Scat of the threatened desert tortoise have been found at the Rock Valley Tank site.

Executive Order 11990 (Federal Register, 1977) specifies that each federal agency "shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities." DOE has taken several actions to ensure compliance with this Order. Data included in Hansen et al. [281] documents and describes NTS wetland locations, boundaries, sizes, animal usage, and presence of field indicators for jurisdictional wetlands classification. This information will be used by DOE to better define the "natural and beneficial values" of NTS wetlands and to develop appropriate ecosystem management goals.

DOE has developed several tools to manage biological resources, including wetlands, on the NTS. These tools include an Ecosystem Geographic Information System wetlands database which is linked with other resource databases to facilitate development and implementation of land and facility use management goals. Specific management goals for the NTS wetlands include (1) avoiding wetland impacts whenever possible, (2) minimizing all unavoidable wetland impacts, (3) restoring the biological integrity of wetlands if degradation occurs, and (4) preserving and enhancing the natural and beneficial values of NTS wetlands. Other recommendations pertaining to the management of NTS natural water sources are described by Hansen et al. [281].

FLORA

The NTS lies on the transition between the Mojave and Great Basin deserts. As a result, elements of both deserts are found in a diverse and complex flora. Extensive floral collections, conducted primarily by Dr. Janice Beatley [86] have yielded 752 taxa of vascular plants within the boundaries of the NTS. About 67 families are represented; however, one-third of the species belong to just three families: Asteraceae (Sunflower Family), Poaceae (Grass Family), and Polygonaceae (Buckwheat Family). With the exception of grasses, perennial species are predominantly low, shrubby species. Several species new to science have been described from material collected on the NTS [297, 551-554], and a number of endemics have been identified.

Vegetation Associations

Prior to the 1990s, Beatley [86] provided the most detailed description of vegetation on the NTS. Her description was based on field observations during the collection of herbarium specimens and on data from 68 permanent vegetation plots studied from 1962 to 1975. The study plot sites were representative of the major kinds of ecosystems in the region. Beatley recognized 19 plant communities on the NTS and developed a map showing nine major vegetation types distributed on the NTS [86].

In 1996, BN biologists started to map vegetation on the NTS. First, ecological landform units (ELUs) having similar physical and biological properties were identified using aerial photographs. Over 1,500 ELUs were verified and sampled from 1996 to 1998. Based on an iterative cluster analysis of the field data collected from the ELUs, 10 vegetation alliances and 20 associations were recognized as occurring on the NTS [507] (Table 2; Figure 16). Alliances and associations were named after the predominant tree or shrub species based on relative abundance and according to Federal Data Committee and Ecological Society of America conventions

Table 2. Vegetation alliances and associations on the NTS.

ECOREGION	ALLIANCE	ASSOCIATION
Mojave Desert	***Lycium*** **spp. Shrubland Alliance**	***Lycium shockleyi-Lycium pallidum*** **Shrubland**
	Larrea tridentata/Ambrosia dumosa **Shrubland Alliance**	***Larrea tridentata/Ambrosia dumosa*** **Shrubland**
	Atriplex confertifolia-Ambrosia dumosa **Shrubland Alliance**	***Atriplex confertifolia-Ambrosia dumosa*** **Shrubland**
Transition Zone	***Hymenoclea-Lycium*** **Shrubland Alliance**	***Lycium andersonii-Hymenoclea salsola*** **Shrubland**
		Hymenoclea salsola-Ephedra nevadensis **Shrubland**
	Ephedra nevadensis **Shrubland Alliance**	***Menodora spinescens-Ephedra nevadensis*** **Shrubland**
		Eriogonum fasciculatum-Ephedra nevadensis **Shrubland**
		Krasheninnikovia lanata-Ephedra nevadensis **Shrubland**
		Ephedra nevadensis-Grayia spinosa **Shrubland**
	Coleogyne ramosissima **Shrubland Alliance**	***Coleogyne ramosissima-Ephedra nevadensis*** **Shrubland**
Great Basin Desert	***Atriplex*** **spp. Shrubland Alliance**	***Atriplex confertifolia-Kochia americana*** **Shrubland**
		Atriplex canescens-Krascheninnikovia lanata **Shrubland**
	Chrysothamnus-Ericameria **Shrubland Alliance**	***Chrysothamnus viscidiflorus-Ephedra nevadensis*** **Shrubland**
		Ericameria nauseosa-Ephedra nevadensis **Shrubland**
	Artemisia **spp. Shrubland Alliance**	***Ephedra viridis-Artemisia tridentata*** **Shrubland**
		Artemisia tridentata-Chrysothamnus viscidiflorus **Shrubland**
		Artemisia nova-Chrysothamnus viscidiflorus **Shrubland**
		Artemisia nova-Artemisia tridentata **Shrubland**
	Pinus monophylla/Artemisia **spp. Woodland Alliance**	***Pinus monophylla/Artemisia nova*** **Woodland**
		Pinus monophylla/Artemisia tridentata Woodland

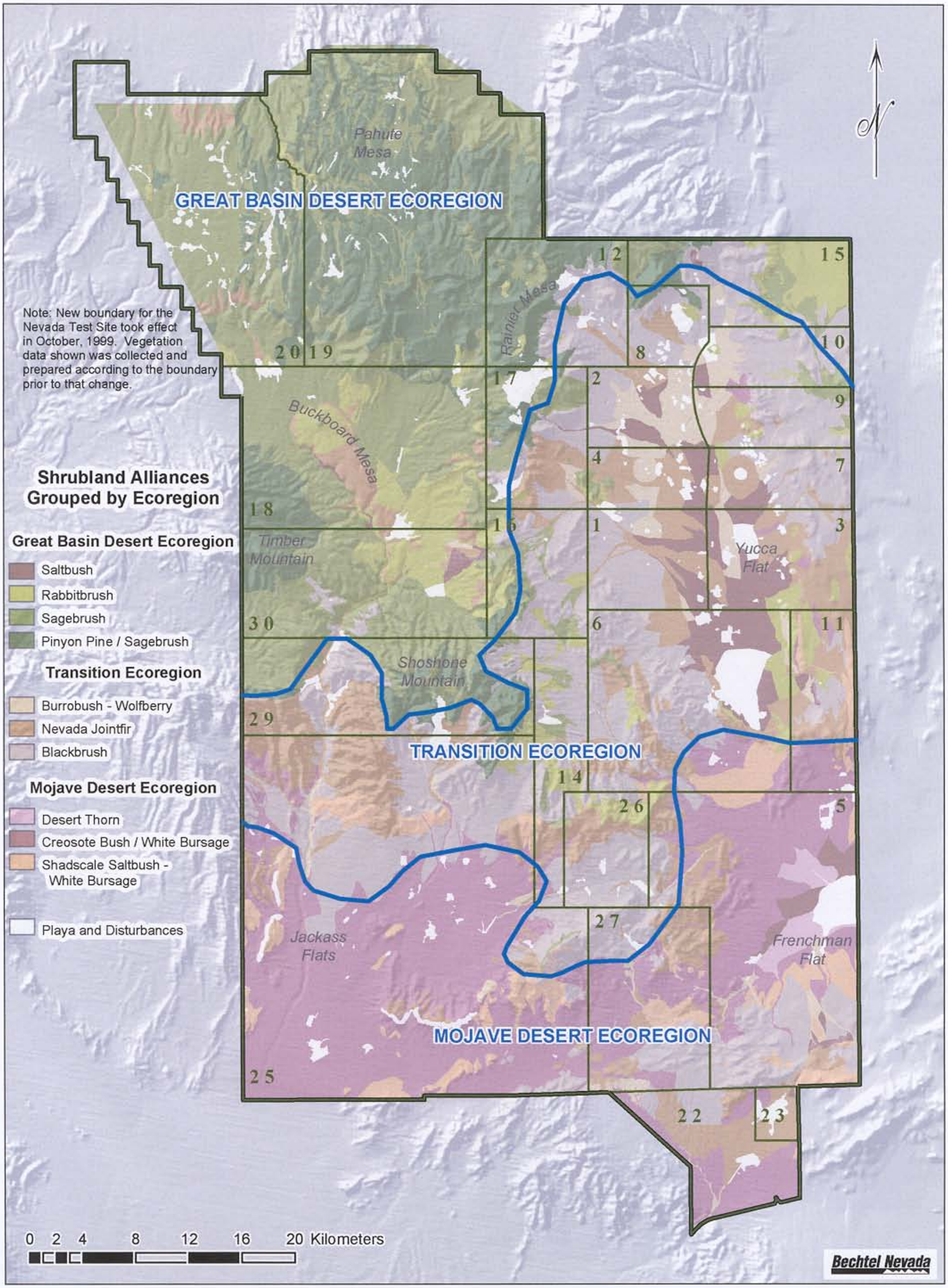

Figure 16. Distribution of plant alliances on the Nevada Test Site

(Grosman et al., 1998; Anderson et al., 1998). There are three alliances within the Mojave Desert, three within the transition zone, and four within the Great Basin Desert. About 4 percent of the 1,508 ELUs sampled were classified as "miscellaneous" because they were unique vegetation types, burned, scraped, or disturbed by nuclear testing. In terms of total area, the Great Basin Desert occupies approximately 40 percent of the NTS, followed by the Transition Zone with 37 percent. The Mojave Desert occupies the southern 22 percent of the NTS.

Associations of *Larrea tridentata* (creosote bush) are characteristic of the Mojave Desert and dominate the vegetation mosaic on the bajadas of the southern NTS, Jackass Flats, and Frenchman Flat (Figure 17). In Yucca Flat, *Larrea* associations are restricted to the upper bajadas in the southwestern and northeastern parts of the drainage. *Larrea* associations reach elevations of 1,372 m (4,500 ft) in favorable locations. The altitudinal and northern distributions of *L. tridentata* are thought to be determined primarily by climatic conditions [827, 81], although soil conditions have also been cited as limiting factors [620]. *Larrea* associations are absent from habitats where the mean minimum air temperature is below -2° C (28.5° F), or the extreme minimum is less than -17° C (1° F). Increased precipitation probably limits the distribution of *L. tridentata* on sites with temperature regimens favorable to the species. *L. tridentata* is limited to zones with an average rainfall of 183 millimeters (mm) (7.2 in) or less [81].

Transitional associations between the Mojave and Great Basin Deserts exist between 1,219 and 1,524

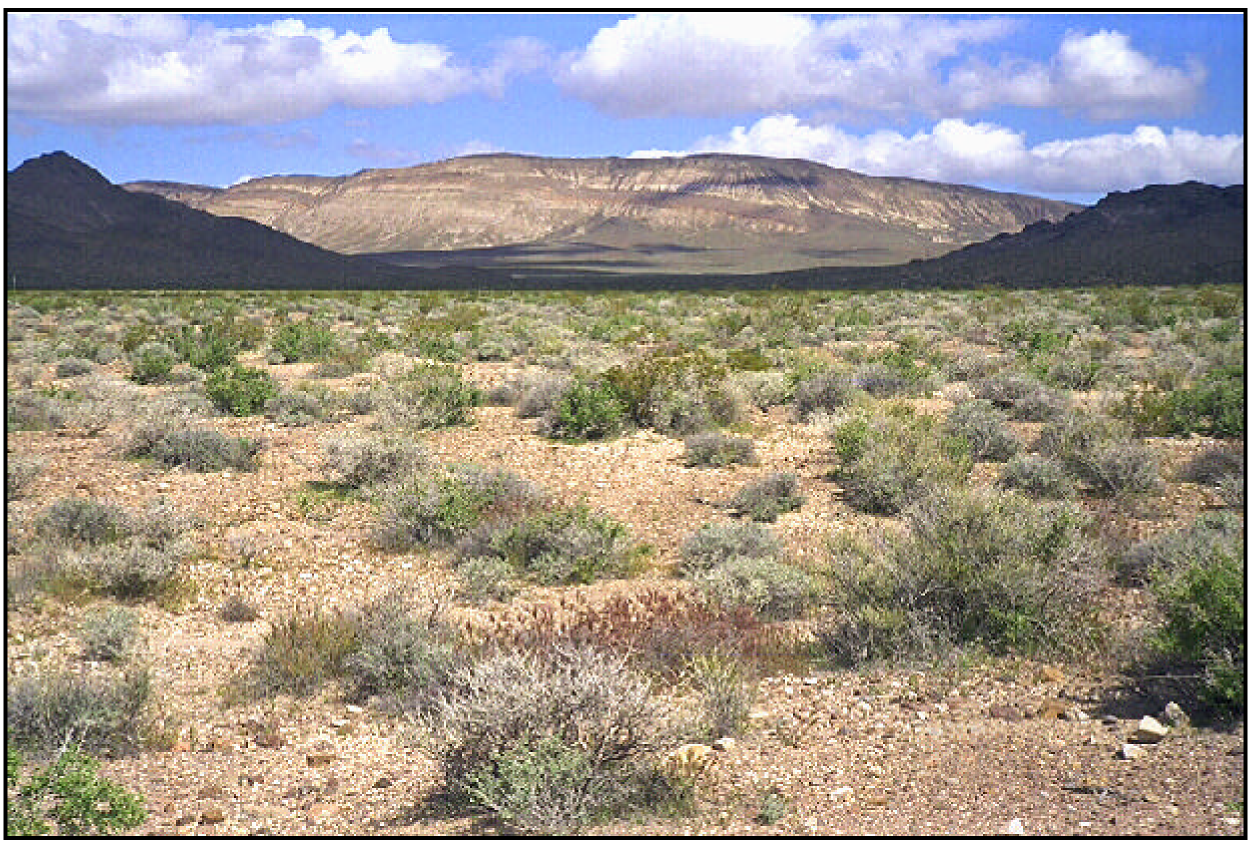

Figure 17. *Larrea tridentata/Ambrosia dumosa* Shrubland Alliance in Rock Valley. This is one of three major alliances within the Mojave Desert ecoregion of the Nevada Test Site.

m (4,000 and 5,000 ft) in elevation. The largest and most important vegetation association in the Transition Zone is the *Coleogyne ramosissima-Ephedra nevadensis* Shrubland Association (Figure 18). It covers 21.6 percent of the total area of the NTS. *Coleogyne ramosissima* (blackbrush) is the dominant species and represents over 50 percent of the relative abundance of shrubs in this association. *Ephedra nevadensis* (Nevada jointfir) is the most common associated shrub species; however, *C. ramosissima* is often so dominant that it forms almost pure stands.
Beatley [86] recognized this plant association and discussed its transitional role between the Mojave and Great Basin Deserts. She stated that it basically belongs to the Mojave Desert, but almost exclusively occupies sites where rainfall exceeds the tolerance of probably many Mojave species. Much of this association has been disturbed on the NTS from testing and natural or man-caused fires. These disturbed areas do not appear to be returning to a *Coleogyne ramosissima* Shrubland Alliance; rather they tend to cluster within the *Ephedra nevadensis* Shrubland Alliance.

In northern Jackass Flat, *C. ramosissima* replaces *L. tridentata* as the dominant shrub. In Yucca

Figure 18. *Coleogyne ramosissima* Shrubland Alliance in northern Mid Valley. This is one of three major alliances within the Transition Zone ecoregion of the Nevada Test Site.

Flat, there are two major transitional associations above the basin floor. On the middle to lower portions of the bajadas, the *Hymenoclea-Lycium* and *Ephedra nevadensis* Shrubland Alliances are dominant, while the upper bajadas support the *Coleogyne ramosissima* Shrubland Alliance. The former alliances appear to occupy sites that have minimum temperatures that are below the tolerances of many Mojave Desert species found in the *Larrea* types, while the latter appear on sites with 178 to 203 mm (7 to 8 in) of annual precipitation and stony, calcareous (especially limestone) soils. Available soil moisture in spring is always highest in the transitional associations as compared with *Larrea* or *Atriplex* alliances [580].

Above 1,524 m (5,000 ft), the vegetation mosaic is characteristic of the Great Basin Desert. There are four alliances within the Great Basin Desert (Table 2), occupying 40 percent of the total area of the NTS. The *Artemesia* spp. Shrubland Alliance represents 18.1 percent of the area of the NTS. The dominant species in this alliance are *Artemisia tridentata* (basin big sagebrush) and *Artemisia nova* (black sagebrush), and *Ephedra viridis* (Mormon tea) and *Chrysothamnus viscidiflorus* (green rabbitbrush) are co-dominants. This alliance occurs throughout the central and northwestern mountains of the NTS (Figure 19). Beatley [86] recognized the *Artemesia* associations within this Great Basin Desert ecoregion, but did not recognize the successional *Ephedra viridis-Artemisia tridentata* Shrubland Association, which is the result of recent fires in the Timber Mountain and Fortymile Canyon areas. The distribution of Great Basin Desert associations appears to be limited by mean maximum temperature and by minimum rainfall tolerances of these "cold" desert species [83].

Figure 19. *Pinus monophylla/Artemisia* spp. Woodland Alliance on Pahute Mesa. This is one of four major alliances within the Great Basin Desert ecoregion of the Nevada Test Site.

The *Pinus monophylla-Artemisia* spp. Woodland Alliance usually occurs at elevations above 1,829 m (6,000 ft) where there is suitable moisture for *Pinus monophylla* (singleleaf pinyon) trees [83]. This alliance consists of two associations (Table 2) and covers 13.3 percent of the area of the NTS. The dominant species in this alliance is *P. monophylla*, and *A. tridentata* and *A. nova* are co-dominants. This alliance occurs throughout the central and northwestern mountains and mesas of the NTS. Beatley [86] recognized a similar plant association, *Artemisia/*Pinyon-Juniper. *Juniperus osteosperma* (Utah juniper) is a common associated species and may be classified as a diagnostic species, but seldom achieves dominance other than in localized conditions at slightly lower elevations such as the northwestern part of Pahute Mesa. Tree densities on the NTS are often not high enough to create closed canopies; rather, the aspect is more of an open woodland type with a mix of shrub and tree cover. This allows for relatively good development of a herbaceous layer, particularly perennial grasses.

Adjacent to the playas in the closed basins of Frenchman and Yucca flats are associations within the Great Basin Desert ecoregion that are dominated by either *Atriplex confertifolia* (shadscale) or *Atriplex canescens* (four-winged saltbush). This *Atriplex* spp. Shrubland Alliance consists of two associations (Table 2) and covers only 3.1 percent of the area of the NTS. It is generally associated with unique soil conditions (either saline, heavy-textured soils, or deep loose sandy soils), and edaphic conditions rather than climatic conditions limit its distribution [83]. Another alliance that is limited by edaphic conditions is the Mojave Desert ecoregion *Lycium* spp. Shrubland Alliance which occurs in Frenchman Flat around the edge of Frenchman Playa. This alliance consists of a single association (Table 2) that is the smallest recognized on the NTS, covering only 0.4 percent of the area of the NTS. The dominant species is *Lycium shockleyi* (Shockley's desert thorn) which is endemic to the broad transition desert of southern Nevada. *Lycium pallidum* (rabbit thorn), a co-dominant species, has a much greater distribution but is still restricted to the Mojave Desert. It reaches its northern limits of distribution at the NTS. Associations containing species of *Lycium* are believed to be controlled by low temperatures [83] and soil salinity [794, 818].

Cover and Production

Shrub coverage within the Mojave Desert types averages about 16 percent with a range of 7 to 23 percent. Transitional vegetation types average 29 percent with a range of 12 to 50 percent, while shrub coverage in Great Basin types averages 24 percent with a range of 15 to 37 percent. Shrub coverage within the various vegetation types is highly correlated with mean annual rainfall. Standing crop of shrubs in Rock Valley is approximately 3,100 kg/ha. Roots contribute about 45 percent by weight to the total [785].

Hansen and Ostler [280] summarized the work of several investigations on standing biomass, cover, and annual primary production on the NTS. Multiple year field measurements of net above-ground annual primary production (NAPP) have occurred at Rock Valley from 1966-1968 and 1971-1976 and at Yucca Mountain from 1989 to 1993. One factor of primary production that becomes evident from these multi-year data is its variability. NAPP at Rock Valley varied from a low of 183 kilograms per hectare (kg/ha) in 1971 to a high of 682 kg/ha in 1973. Turner and Randall [742] showed that the NAPP of shrubs was highly correlated ($r=0.95$) with precipitation. They derived a formula that predicted NAPP from precipitation for the Mojave Desert at the NTS: $NAPP=0.31(PPT)-8.35$, where PPT is the precipitation (in mm) occurring from September to August during that growing year. This equation predicts zero NAPP at or below 26.9 mm of PPT. This corresponds to empirical evidence reported by Beatley [82] for annual plant germination and growth, and predicts that there can be years when there is essentially no NAPP. This was observed in data reported at Yucca Mountain during the drought of 1988-1990. The result of this is often the death of less adaptive species or the loss of living above-ground biomass which was observed and documented at Yucca Mountain [634].

In wet years, winter annual forbs and grasses can become the dominant species of ground cover and be a major contributor to the annual production of biomass. However, the majority of winter annual seedlings do not survive to maturity. Studies have shown that following autumn germination approximately 38 percent (with a range from 10 to 63 percent) reach maturity. After heavy rains and spring germination, about 60 percent (with a range from 44 to 83 percent) survive. Inadequate soil moisture is the principal cause of mortality in germinated winter annuals [72]. As with shrubs, the NAPP of annuals at the NTS is highly correlated to precipitation (September-March) [622]. Data on NAPP from annuals has been studied at Rock Valley from 1966-1976 [622] and at Yucca Mountain from 1989-1994 [294]. NAPP of annuals ranged from a low of 0.0 kg/ha during the drought years of 1989-90 to a high of 688 kg/ha in 1973 when the Rock Valley site received 218 mm of precipitation from September 1972 to March 1973.

The allocation of NAPP in annuals to shoot, root, and reproductive tissue has been studied during a six-year period from 1971-1976 [622]. Unlike shrubs where over 50 percent of NAPP is below-ground, annuals contribute on an average only 6.6 percent which is similar to other studies of desert annuals in the southwestern United States (Bell et al., 1979; Forseth and Ehleringer, 1982). Approximately 44 percent of the biomass of annuals is allocated to reproduction which is equally split between flowers and fruits.

Biomass of winter annuals has been measured in Mojave Desert vegetation types (19 to 160 kg/ha [143 lbs/ac]), Transition Zone vegetation types (35 to 180 kg/ha), and Great Basin Desert vegetation types, (25 to 62 kg/ha) [73]. Burned sites consistently produce more winter annual biomass. Over a 3-year sampling period, Beatley [73] measured 2 to 11 times more production in burned sites than on undisturbed sites, due primarily to the presence of alien grasses, principally the *Bromus* species.

Invasive Species

Invasive species are those which are not native to the NTS ecosystem and which may cause environmental harm. *Bromus rubens* (red *brome*) and *Bromus tectorum* (cheatgrass) are winter annual grasses, and *Salsola iberica* and *Salsola paulsenii* (two species of Russian thistle) are summer annual forbs. These four invasive species have become important components within the vegetation mosaic. All rapidly invade disturbed sites, extract soil water and soil nutrients effectively, and delay revegetation of areas by native species. *B. tectorum* is found on disturbed sites at elevations above 1,524 m (5,000 ft) in the *Artemisia* vegetation types. This species has increased its distribution and abundance on the NTS over the years as higher elevations became disturbed for operational uses [313]. *B. rubens* is found at middle elevations and is frequently the dominant winter annual in *Coleogyne* types. It can be found on undisturbed sites, but does not appear to be as aggressive as *B. tectorum* [68].

Current studies on the ecophysiology of *Bromus* species have been conducted at the Nevada Desert FACE Facility in Frenchman Flat operated by the Desert Research Institute [348-350, 353, 865].

Salsola sp. are restricted to disturbed sites where the physical characteristics of the soil surface have been modified and the shrubs killed. Germinating *Salsola* sp. cannot penetrate compacted soils; therefore, it must have some scarification of the soil surface to be successful [789]. *Salsola* sp. also require warm soil temperatures, but only moderate soil moisture. Transpiration in *Salsola* sp. is influenced more by soil temperature than soil moisture, and these summer annuals appear to have 1/3 to 1/2 the moisture requirements of most crop plants [789].

Under Executive Order 13112 (Federal Register, 1999), federal agencies are mandated, to the extent practicable, to prevent and control the spread of invasive species, restore native species and habitat conditions, and conduct research on invasive species to develop technologies to prevent their introduction and spread.

Ecophysiology

The following summary is reproduced in large part from O'Farrell and Emery [498]. It is, therefore, a synthesis of NTS plant ecophysiology data gathered only through 1975. The reader is encouraged to use the keyword index to identify all vegetation-related publications which are not referenced or summarized in the following paragraphs.

Knowledge of the physiological characteristics of NTS flora has been developed in glass-house and laboratory studies. The information has been valuable in developing hypotheses concerning the mechanisms which might control the observed relationships between species distribution and the climatic and edaphic conditions of this arid region. Field observations have pointed out the importance of air and soil temperatures in the distribution of vegetation types on the NTS [81, 83]. Controlled experiments have also shown that temperature is important for the growth of desert shrub seedlings, and that temperatures might, under many conditions, help regulate the distribution of shrubs. Seedlings of shrubs characteristic of the Great Basin Desert show decreased growth with increasing soil temperatures in the range of 16 to 28° C (60 to 83° F). Seedlings of Mojave Desert species show increased growth with increasing soil temperatures, while species from transitional habitats usually grow best at intermediate temperatures [790].

Growth rates of plants under variable temperature regimens are closely related to the pathways involved in the photosynthetic fixation of CO_2. In general, species adapted to cold habitats are associated with the Calvin cycle, while species adapted to hot temperatures are associated at least in part with the C_4 pathway. When 14 species from the NTS were studied, only *A. canescens* and *A. confertifolia* exhibited characteristics of the C_4 pathway only. The other species demonstrated characteristics of both pathways, suggesting that gradations between extremes of the two photosynthetic systems can occur in the same species [809]. Another physiological adaptation involves the ability of some plants to respond to water vapor in the air as part of their moisture economy strategy. Species of *Atriplex* have the ability to absorb water from vapor through their leaves. *L. tridentata* absorbs only small amounts of water through its leaves, but there is evidence that if *L. tridentata* is preconditioned it is able to survive for periods with water from a vapor source only [779].

Several species of plants demonstrate a physiological tolerance to high concentrations of minerals, especially salts, in the soil. The tolerance is often associated with the ability to concentrate both cations and anions in vegetative parts such as leaves, which can then be dropped with their concentrated minerals [788, 794, 812]. The anion and cation contents of plants are determined by the concentrations in the soils and the species of plant. Species of *Atriplex* accumulate up to 10 percent dry weight of sodium, chlorine, and potassium in their top leaves [788], *Lycium andersonii* (Anderson's wolfberry) accumulates lithium [794], *Grayia spinosa* (spiny hopsage) concentrates potassium, and *Atriplex hymenelytra* (desert holly) accumulates cadmium [812]. Some species do not tolerate high levels of salts. *L. tridentata* fails to grow where the soil C horizon is highly saline and where the A horizon contains over 10 milli-equivalents per 100 grams exchangeable potassium [794].

The ability to concentrate certain elements has also contributed to the toxic quality of certain species of plants on the NTS. At least 30 species have been identified as being poisonous to animals, especially domestic livestock [134]. The majority of species are not poisonous in the colloquial sense, but must be consumed in large quantities to be lethal. Most poisonous plants will be avoided by livestock if suitable forage species have not been depleted by overgrazing. At least nine species are potentially dangerous as they are lethal in small quantities [134].

Soil fungi are considered to be important, even necessary, for the absorption of certain elements from the soil by plants. Symbiotic mycorrhizae, root fungi, associated with *Ambrosia* and the grass *Pleuraphis rigida*, are necessary for phosphorus absorption in soils that are not well supplied with available phosphorus [787]. Other components within desert soils have a negative effect upon growth of plants. A degree of allelopathy has been demonstrated in soils taken from under existing or recently dead shrubs. Growth of new plants is decreased in such soils [787].

Also important to plant growth and production is the abundance of CO_2 that is increasing in the earth's atmosphere. Researchers at the Nevada Desert FACE Facility in southern Frenchman Flat have been conducting research on the impacts of increased levels of CO_2. They are investigating the impacts on root and shoot growth, annual productivity, and possible changes that could occur to the desert ecosystem.

FAUNA

Invertebrates

Invertebrates comprise the majority of animals on the NTS, both in terms of numbers of species and relative abundance [28]. Approximately 1,200 invertebrate species, representing 4 phyla, 12 classes, 43 orders, and 209 families have been documented to occur on the NTS. These probably represent only a fraction of the species that actually live in the diverse habitats on the NTS. Most of the extensive and intensive sampling programs were designed to collect arthropods, and little is known about the species diversity, distribution, or roles of the soft-bodied invertebrates. In fact, 99 percent of the documented species are arthropods. The remaining 1 percent includes 1 species of annelid, 2 species of mollusks (Greger, 2000), and 14 species of nematodes [212, 214].

Of the 1,182 species of arthropods, 78 percent are insects. The remaining species are divided among 6 classes (Arachnida, Branchiopoda, Malocostraca, Maxillopoda, Chilopoda, and Diplopoda); however, 91 percent of these represent spiders and their close allies; mites and sunspiders.

A total of 100 species of spiders, representing 29 families, has been identified [24]. They are found in every vegetation alliance, but are most numerous in collections from the *Coleogyne ramosissima* Shrubland Alliance. The greatest species diversity occurs in transitional vegetation types such as *Hymenoclea-Lycium*, *Ephedra nevadensis*, and *Coleogyne ramosissima* Shrubland Alliances [28].

Twenty-nine species of Solpugids and nine species of scorpions are found principally in the Mojave Desert and transitional vegetation types [13, 241, 473, 474]. Both groups are most abundant in the *Larrea-Ambrosia* Shrubland Alliance, but most species are found to be in *Hymenoclea-Lycium* and *Ephedra nevadensis* Shrubland Alliances [28]. Three species of Phalangids or harvestmen are found in all vegetation types [8], but they are most abundant in the *Coleogyne ramosissima* Shrubland Alliance [28].

Other important spider relatives found on the NTS include mites and ticks. Both groups have been implicated as vectors for pathogens and parasites affecting plants and animals. Consequently, efforts have been made to describe host relationships as well as taxonomic status. Fifteen species of ticks have been identified [100, 130, 289,] and 76 species of mites have been described along with their apparent hosts [5-7, 17, 22, 25, 26, 129, 176, 209, 236, 253, 363, 366, 510, 739].

Exclusive of insects, the remaining taxa of arthropods include: three species of anostracans, one species of cladocerans, one species of conchostracans, one species of notostracans, one species of decapods, two species of isopods [27], two species of copepods, two species of ostracods, seven species of centipedes [12, 141, 142, 143], and four species of millipedes [140]. None of these groups appears to be either numerous or widespread [28].

The 924 species of insects which are presently known from the NTS represent 17 orders and 113 families. Two-hundred nineteen species of Coleoptera, beetles, have been collected [23, 61, 176, 209, 361, 700-704]. They belong to 28 families, but most species belong in the Family Tenebrionidae, the darkling beetles. These large, mostly black, ground-dwelling beetles are an important component of the fauna in arid and semiarid regions of western North America. The greatest number of species are found in the *Larrea-Ambrosia* Shrubland Alliance, but they are most numerous in *Hymenoclea-Lycium* and *Ephedra nevadensis* Shrubland Alliances. The most widespread species is *Eleodes obscura*, which is one of the largest darkling beetles. Beetles have been captured in all months of the year, but most are seasonally abundant depending on whether they are spring-emergent or fall-emergent species [28].

There are 190 species within the Order Hymenoptera which includes the ants, bees, and wasps [10, 14, 153-155, 201, 355, 820]. Members of 14 families have been identified. Ants are most abundant in the *Hymenoclea-Lycium* and *Ephedra nevadensis* Shrubland Alliances and the *Pinus monophylla-Artemisia* spp. Woodland Alliance, and the greatest number of species are also found in the latter vegetation type [28]. Ants are most active seasonally between spring and autumn, although some species are found in all months. Within seasons, their activity above-ground is correlated closely with soil temperature, moisture, and availability of food.

Approximately 192 species within the Order Heteroptera, true bugs, have been identified [16, 381]. Eleven families are represented, but 161 of the 192 known species belong to the Family Miridae: plant bugs. This is a biased picture, which reflects more closely the importance of taxonomic scrutiny rather than the true species composition within the Order Heteroptera on the NTS. A Miridae specialist reviewed material collected on the site and was able to describe 7 new genera and 97 new species [381].

A similar situation occurs within the Order Diptera, flies, where only the members of the Family Bombyliidae have been reviewed by taxonomic authorities. They were able to identify and describe 111 species [32]. There are currently 121 species of dipterans, representing 7 families on the NTS.

The remaining insects are classified as follows: Order Blattodea, 1 family, 3 species; Order Embioptera, 1 family, 1 species; Order Ephemeroptera, 2 families, 2 species; Order Homoptera, 6 families, 17 species; Order Isoptera, 2 families, 3 species [475]; Order Lepidoptera, 20 families, 78 species [11]; Order Mantodea, 1 family, 2 species; Order Odonata, 2 families, 2 species; Order Orthoptera, 8 families, 53 species [60]; Order Phasmatodea, 1 family, 2 species; Order Siphonaptera, 6 families, 36 species [97, 283]; Order Thysanoptera, 2 families, 2 species; and Order Trichoptera, 1 family, 1 species.

Many insect species living on the NTS are still unknown. Many specimens have been collected and deposited in appropriate museums, but there are no authorities available to make taxonomic identifications for many major groups [99]. This is an important problem at the NTS where so many insects are new to science and require species descriptions. As several other sampling schemes are used in major vegetation associations, and as more taxa are reviewed by specialists, important additions will be made to the species lists of insects.

The functional roles of most insects on the NTS are still poorly known. Ants and termites are probably the most important groups of insects on the NTS and many major desert habitats. Both groups contribute a large proportion to both the numbers and biomass of the fauna of arid lands. Ants harvest large quantities of the annual production of the vegetation, especially seeds and fruits. Termites aid in the reduction of woody material that would otherwise decompose slowly in the arid, hot environment, and both groups are involved in the degradation of vegetative products and the recycling of important nutrients within the soil.

Fish

Goldfish (*Carassius auratus*), golden shiners (*Notemigonus crysoleucas*), and bluegills (*Lepomis machrochirus*) have been unofficially introduced into ponds associated with wells, and represent the only fish species known to occur on the NTS. They breed successfully and the goldfish display the diversity of color patterns and sizes associated with the species.

Amphibians

The range of the Great Basin spadefoot toad (*Scaphiopus intermontanus*) is thought to overlap the NTS (Stebbins, 1985), but it has not been located near the ponds or springs or in the more mesic pinyon- juniper woodlands of the NTS. Bullfrogs (*Rana catesbeiana*) occur in some man-made ponds in Areas 3 and 6 and represents the only amphibian species known to occur on the NTS. Bullfrogs are not native to the southwest United States, and where this species has become established, it has adversely affected populations of native frogs. It is not known how they were introduced onto the NTS.

Reptiles

The reptilian fauna of the NTS includes one species of tortoise (see Protected Species), 16 species of lizards, and 17 species of snakes [28, 119, 705, 706, 710, 851].

The rich lizard fauna is partly due to the overlapping ranges of species characteristic of the Mojave and Great Basin Deserts. Several species show affinities with their place of origin by their patterns of distribution within the NTS vegetation types [705, 710]. Species found mainly in Mojave Desert vegetation types include: banded gecko (*Coleonyx variegatus*), desert iguana (*Dipsosaurus dorsalis*), collared lizard (*Crotaphytus insularis*), chuckwalla (*Sauromalus obesus*), and desert night lizard (*Xantusia vigilis*). The following lizards are found in both Mojave Desert and transitional vegetation alliances: Gilbert's skink (*Eumeces gilberti*), zebra-tailed lizard (*Callisaurus draconoides*), desert spiny lizard (*Sceloporus magister*), and western whiptail (*Cnemidophorus tigris*). Three species are confined to Great Basin Desert vegetation alliances: sagebrush lizard (*Sceloporus graciosus*), western fence lizard (*Sceloporus occidentalis*), and western skink (*Eumeces skiltonianus*). The side-blotched lizard (*Uta stansburiana*) is found in all vegetation types, and the leopard lizard (*Gambelia wislizenii*) and desert horned lizard (*Phrynosoma platyrhinos*) are found everywhere but in pinyon-juniper. The banded gila monster (*Heloderma suspectum*) is also thought to occur on the NTS (see Protected Species).

Based on their widespread distribution and relative abundance compared with other species, the most important lizards on the NTS are reported to be the side-blotched lizard (Figure 20) and the western whiptail (Figure 21) [710, 851]. Side-blotched lizards are abundant, and are found in all vegetation types and throughout the altitudinal gradient. Western whiptails are second only to *U. stansburiana* in abundance on the NTS and are found in Mojave Desert and transitional vegetation alliances.

Figure 20. Side-blotched lizard (*Uta stansburiana*). This is the most abundant lizard on the Nevada Test Site and is found in all ecoregions. (Photo from U.S. Geological Survey/Chris Brown photographer)

Snakes on the NTS are observed very infrequently, which has made it difficult to describe their relative

Figure 21. Western whiptail (*Cnemidophorus tigris*). This species is found in Mojave Desert and Transition Zone vegetation types and is the second most abundant species of lizard on the Nevada Test Site. (Photo from U.S. Geological Survey/Chris Brown photographer)

abundance, habitat preferences, or seasonal patterns of activity. Present information suggests that the western shovel-nosed snake (*Chionactis occipitalis*) (Figure 22) is the most common snake on the NTS, especially over much of the bajadas [710].

Four snake species on the NTS are poisonous: Mojave Desert sidewinder (*Crotalus cerastes*), Panamint rattlesnake (*C. mitchelli*) (Figure 23), night snake (*Hypsiglena torquata*), and the Sonora lyre snake (*Trimorphodon lambda*). The night snake and lyre snake are small snakes that

Figure 22. Western shovel-nosed snake (*Chionactis occipitalis*). This small snake is probably the most common on the Nevada Test Site and is found in the Mojave Desert and Transition Zone ecoregions. **(Photo by Phil Medica)**

Figure 23. Panamint rattlesnake (*Crotalus mitchelli*). It is one of four venomous snakes on the Nevada Test Site and is found within all ecoregions.

inject venom with enlarged, grooved teeth toward the back of their upper jaws. They are seldom seen and pose no known threat to humans. The rattlesnakes are larger, more conspicuous, and must be avoided or treated with caution and respect owing to their potentially dangerous bite.

Birds

There are records of 239 species of birds observed on the NTS [28, 113, 139, 264, 265, 286, 573, 622]. They are widely distributed but appear to be most common in the *Hymenoclea- Lycium* and *Ephedra nevadensis* Shrubland Alliances. The greatest species diversity occurs in contrasting vegetation types: *Pinyon*-Juniper and *Larrea-Ambrosia*. The most widely distributed species are the Blackthroated Sparrow (*Amphispiza bilineata*), House Finch (*Carpodacus mexicanus*), Red-tailed Hawk (*Buteo jamaicensis*), Common Raven (*Corvus corax*), Loggerhead Shrike (*Lanius ludovicianus*), Northern Mockingbird (*Mimus polyglottos*), Ash-throated Flycatcher (*Myiarchus cinerascens*), and Mourning Dove (*Zenaida macroura*) [28].

Approximately 80 percent of the bird species are either transients that migrate through the area during spring and fall, or are seasonal residents [28, 286, 264]. Only the following species are considered year-round residents of the NTS: Turkey Vulture (*Cathartes aura*), Cooper’s Hawk (*Accipiter cooperii*), Sharp-shinned Hawk (*Accipiter striatus*), Golden Eagle (*Aquila chrysaetos*), Red-tailed Hawk, Prairie Falcon (*Falco mexicanus*), American Kestrel (*Falco sparverius*), Chukar (*Alectoris chukar*), Gambel's Quail (*Callipepla gambelii*), American Coot (*Fulica americana*), Greater Roadrunner (*Geococcyx californianus*), Common Barn Owl (*Tyto alba*), Burrowing Owl (*Athene cunicularia*), Great Horned Owl (*Bubo virinianus*), Northern Flicker (*Colaptes auratus*), Hairy Woodpecker (*Picoides villosus*), Say's Phoebe (*Sayornis saya*), Horned Lark (*Eremophila alpestris*), Northern Rough-winged Swallow (*Stelgidopteryx serripennis*), Violet-green Swallow (*Tachycineta thalassina*), Western Scrub Jay (*Aphelocoma californica*), Common Raven, Pinyon Jay (*Gymnorhinus cyanocephalus*), Mountain Chickadee (*Poecile gambeli*), Bushtit (*Psaltriparus minimus*), Cactus Wren (*Campylorhynchuys brunneicapillus*), Rock Wren (*Salpinctes obsoletus*), Bewick’s Wren (*Thryomanes bewickii*), Mountain Bluebird (*Sialia currucoides*), Western Bluebird (*Sialia mexicana*), Le Conte’s Thrasher (*Toxostoma lecontei*), Loggerhead Shrike, European Starling (*Sturnus vulgaris*), Sage Sparrow (*Amphispiza belli*), Dark-eyed Junco (*Junco hyemalis*), Spotted Towhee (*Pipilo maculatus*, formerly the Rufous-sided Towhee [*Pipilo erythrophthalmus*]), Lesser Goldfinch (*Carduelis psaltria*), House Finch, and House Sparrow (*Passer domesticus*) [264, 286].

During the spring and summer, seasonal residents increase the species diversity in a number of habitats. Spring/summer seasonal residents are believed to include: Swainson's Hawk (*Buteo swainsoni*), Mourning Dove, Lesser Nighthawk (*Chordeiles acutipennis*), Common nighthawk (*Chordeiles minor*), Common Poor-will (*Phalaenoptilus nuttallii*), White-throated Swift (*Aeronautes saxatalis*), Costa's Hummingbird (*Calypte costae*), Broad-tailed Hummingbird (*Selasphorus platycercus*), Lewis’s Woodpecker (*Melanerpes lewis*), Ladder-backed Woodpecker (*Picoides scalaris*), Western Wood Pewee (*Contopus sordidulus*), Hammond’s Flycatcher (*Empidonax hammondii*), Gray Flycatcher (*Empidonax wrightii*), Black Phoebe (*Sayornis nigricans*), Ashthroated Flycatcher, Western Kingbird (*Tyrannus verticalis*), Cassin's Kingbird

(*Tyrannus vociferans*), Steller's Jay (*Cyanocitta stelleri*), Clark's Nutcracker (*Nucifraga columbiana*), Plain Titmouse (*Parus inornatus*), White-breasted Nuthatch (*Sitta carolinensis*), Canyon Wren (*Catherpes mexicanus*), House Wren (*Troglodytes aedon*), Blue-gray Gnatcatcher (*Polioptila caerulea*), Northern Mockingbird (*Mimus polyglottos*), Warbling Vireo (*Vireo gilvus*), Solitary Vireo (*V. solitarius*), Gray Vireo (*V. Vicinior*), Black-throated Gray Warbler (*Dendroica nigrescens*), Virginia's Warbler (*V. virginiae*), Lazuli Bunting (*Passerina amoena*), Black-headed Grosbeak (*Pheucticus melanocephalus*), Black-throated Sparrow, Brewer's Sparrow (*Spizella breweri*), Chipping Sparrow (*Spizella passerina*), Northern Oriole (*Icterus galbula*), Scott's Oriole (*I. parisorum*), Brown-headed Cowbird (*Molothrus ater*), Great-tailed Grackle (*Quiscalus mexicanus*), and Cassin's Finch (*Carpodacus cassinii*) [264, 286]. Spring and summer seasonal residents are important because some of them breed on the NTS. A total of 36 species of birds has been documented as breeding on the NTS [113, 139, 264, 286, 295, 730, 731, 739].

For such an arid location, there are a surprising number of transient waterfowl and shore birds. Waterfowl observed on the NTS include 17 species of ducks, 2 species of geese, 1 swan species, and 2 mergansers. Shore birds observed include 6 species of plovers, the Black-necked Stilt (*Himantopus mexicanus*), the American Avocet (*Recurvirostra americana*), 17 species of sandpipers and phalaropes, and 8 species of gulls and terns. They find suitable habitats near the springs, well ponds, and the temporary lakes formed when surface runoff waters collect in Yucca and Frenchman playas [264, 286]. In addition to waterfowl, the only game birds found on the NTS are Gambel's Quail, Chukar, and Mourning Dove.

In winter, the NTS provides feeding grounds for thousands of small passerine birds including the following: Sage Sparrow, House Finch, Dark-eyed Junco, European Starling, White-crowned Sparrow (*Zonotrichia leucophrys*), Pine Siskin (*Carduelis pinus*), American Goldfinch (*Carduelis tristis*), and Horned Lark [264, 573]. Most of these birds have been observed throughout the year on the NTS [264], but they are found in much larger numbers during the winter. Horned Larks are the most common wintering species and often are seen in flocks of over 2,500 birds. House Finches are also seen in flocks numbering between 300 to over 2,500 birds. Vegetation types disturbed by past nuclear testing seem to provide excellent supplies of winter food, especially seeds, particularly if large stands of Russian thistle and brome grasses are present [264, 573].

Observations of raptors have been recorded and more formal raptor surveys have been conducted on the NTS throughout the years [93-95, 261, 262, 264, 265, 404]. Observational data suggest that the abundance of some hawks on the NTS have declined over the last decade. In the 1960s, Hayward et al. [286] reported frequent sightings of Ferruginous, Swainson's, and Rough-legged hawks on the NTS, but these three species were rarely observed over a three-year period from 1989 to 1991 by Greger and Romney [265]. They were also rarely observed during raptor surveys conducted along roads in Jackass Flats and on Yucca Mountain between 1991 to 1995 [404]. The most commonly seen raptors on the NTS are the Red-tailed Hawk, Golden Eagle, Turkey Vulture, and American Kestrel [261, 262, 264, 265, 404]. Eight species of raptors are known to breed on the NTS. With the exception of the ground-dwelling Western Burrowing Owl (see Protected Species), Red-tailed Hawks (Figure 24) were found to have the most nests (seven) and produced the greatest numbers of young (ten in 2000) among breeding raptors observed on the NTS from 1998 through 2000 [95].

Figure 24. Red-tailed Hawk (*Buteo jamaicensis*). Cliff nests and Joshua tree nests of this species are the most commonly found raptor nests on the Nevada Test Site.
(Photo by Paul Greger)

Mammals

A total of 44 terrestrial mammals and 16 species of bats has been recorded on the NTS [19, 28, 368]. Rodents account for about 40 percent of the known species, and in terms of distribution and relative abundance, are the most important group of mammals on the NTS. Most of the rodents belong to two important families: Heteromyidae, which includes the kangaroo rats and pocket mice; and Cricetidae, the New World mice.

Several of the rodent species are typical of the Mojave Desert including: round-tailed ground squirrel (*Spermophilus tereticaudus*), Merriam's kangaroo rat (*Dipodomys merriami*) (Figure 25), southern grasshopper mouse (*Onychomys torridus*), and cactus mouse (*Peromyscus eremicus*) (Figure 26). They are generally observed or trapped in the Mojave vegetation types on the NTS, and to a lesser degree, in some of the transitional vegetation types [86, 259, 368, 628]. Other species are representative of the Great Basin Desert: Townsend's ground squirrel (*Spermophilus townsendii*), Great Basin pocket mouse (*Perognathus parvus*), Ord's kangaroo rat (*Dipodomys ordii*), Great Basin kangaroo rat (*Dipodomys microps*), and sagebrush vole (*Lagurus curtatus*) [86, 368, 628]. They have been sampled primarily in the transitional and Great Basin vegetation types. The little pocket mouse (*Perognathus longimembris*) was common in both the Mojave and transitional

Figure 25. Merriam's kangaroo rat (*Dipodomys merriami*). Four species of kangaroo rats have been trapped on the Nevada Test Site. Merriam's is the most common within the Mojave Desert ecoregion.

Figure 26. Cactus mouse (*Peromyscus eremicus*). Four species of *Peromyscus* have been trapped on the Nevada Test Site. The cactus mouse inhabits the Mojave Desert ecoregion.

vegetation types until a drought occurred in the late 1980s. Since then, this species appears to have recovered in the Mojave vegetation type but not in the transitional vegetation type [259, 628].

Greater numbers of rodent species are trapped in *Hymenoclea-Lycium*, *Ephedra nevadensis*, and *Coleogyne Shrubland* Alliances, while the fewest species are captured in *Larrea-Ambrosia* and *Lycium* spp. Shrubland Alliances [19, 628]. However, the transitional nature of the vegetation types, soils, altitudinal gradients, and microclimates presents enough permutations so that interactions between small mammals and preferred vegetation types cannot presently be described quantitatively. The relationships can be used in some cases as qualitative indicators. For example, there is a change from *Dipodomys ordii* and *D. microps* in the northern Great Basin vegetation types, to *D. merriami* in the *Larrea-Ambrosia* vegetation types in the southern part of the NTS.

The abundance of small mammals is quite variable among species, years, vegetation types, and locations. Populations respond quickly to periods of good vegetative growth. They can reproduce in a matter of weeks, and can increase their densities at least five-fold within one breeding season [233]. There is an apparent correlation between production of winter annual plants and reproduction in desert rodents on the NTS [74].

Populations of small mammals, especially those in Rock Valley, have been sampled intensively over the years, and excellent information has been gathered on population dynamics, seasonal activities, food habits, movements and home ranges, and responses to chronic radiation exposure [227, 228, 230, 233, 259, 437, 628]. Comparatively little is known about the populations of medium-sized and large mammals of the NTS.

The black-tailed jackrabbit (*Lepus californicus*) is the most conspicuous and widespread species of the larger mammals. It has been observed in all vegetation associations from the valley floors to the pinyon-juniper woodlands [368, 682]. Little is known about their densities or population dynamics on the NTS, and there is no evidence that they ever reach high densities, which seems to be characteristic of species elsewhere in western North America. Two close relatives, the desert cottontail (*Sylvilagus audubonii*) and Nuttall's cottontail (*S. nuttalii*), are also found on the NTS. The former is more numerous, and is found in all vegetation types. Nuttall's cottontail is restricted to the higher elevations in the Great Basin vegetation types [368].

The most important carnivores include: coyote (*Canis latrans*), kit fox (*Vulpes macrotis*) (Figure 27), badger (*Taxidea taxus*), bobcat (*Lynx rufus*), mountain lion (*Felis concolor*), and long-tailed weasel (*Mustella frenata*). The coyote is the most widely distributed, conspicuous, and probably most numerous of the predatory mammals. The mountain lion is perhaps the most secretive, least numerous of the predators. It appears to be most common on the northern mesas [264, 368], but occurs throughout the NTS.

Mule deer (*Odocoileus hemionus*) are the most numerous large mammal, and can be found during all seasons on the high mesas in the Great Basin vegetation types and to a lesser extent in the transitional vegetation types of the NTS [368]. Giles and Cooper [250] conducted a study to determine the seasonal movements of mule deer on the NTS. They found that during the winter, most deer

Figure 27. Kit fox (*vulpes macrotis*). On the Nevada Test Site, this species commonly occurs in valleys and surrounding foothills within Mojave Desert and Transition Zone vegetation associations.

move off of Pahute and Rainier mesas into lower elevations on and off the NTS. They also estimated the deer population to be around 1,500 to 2,000 animals in 1981. However, deer spotlighting surveys conducted through the 1990s revealed a strong downward trend in deer numbers, which is possibly due to a decrease in the number of available water sources on the mesas [95, 264].

Pronghorn antelope (*Antilocapra americana*) sometimes occur in Yucca Flat and in Frenchman Flat in small numbers. Desert bighorn sheep (*Ovis canadensis*) are thought to be rare visitors on the site. There have been a few sightings of bighorn sheep in Mercury and on Rainier Mesa, but they do not appear to reside permanently anywhere on the NTS.

Feral horses (*Equus caballus*) reside almost exclusively in an area approximately 325 km^2 (125 mi^2) within and around the Eleana Range. This area is between about 1,300 and 2,000 m (4,264 and 6,560 ft), the lower elevations of the Great Basin Desert on the NTS. Horses were first systematically studied on the NTS in 1988, when use of water sources by wildlife was documented. In 1989, a program was initiated to estimate the abundance of horses annually. That monitoring has continued through 2000 and has provided excellent information on the abundance, recruitment (i.e., survival of horses to reproductive age), and distribution of the horse population on the NTS [93-95, 261-265, 586].

The abundance of horses was relatively stable at 61 to 65 animals >1 year old during 1990 to 1993. The population began declining in 1994. The population size in 2000 was estimated to be 37 [95]. The sex ratio was stable during 1990 to 1998 at about 0.78 males per female. The cause of this decline appears to be (1) low recruitment due to very poor foal survival and (2) moderate adult mortality since 1993. Greger and Romney [266] suggested that low foal survival was due in part to mountain lion predation. Low foaling rates (26 to 50 percent) also may have contributed to the poor recruitment, although foaling rates may have been underestimated if foals died very soon after birth. It is also possible that some horses in this population are past their prime reproductive age, resulting in lower foal production and more adults dying of causes related to old age.

Burros (*Equus asinus*) are common in several areas bordering the NTS. They have been sighted only rarely, however, on the NTS.

Fifteen species of bats are known to occur on the NTS [276, 532, 687]. Two species have been identified by analysis of their recorded ultrasonic calls (O'Farrell, 2000; 2001). Seven of the 16 bats are considered species of concern by the U.S. Fish and Wildlife Service (see Protected Species). The most important species in terms of abundance and distribution is the western pipistrelle (*Pipistrellus hesperus*), which occurs throughout the NTS. The western pipistrelle, California myotis (*Myotis californicus*), and pallid bat (*Antrozous pallidus*) are the most common bat species found in the Mojave vegetation types, and the western pipistrelle and California myotis are the most common bat species found in the transition vegetation types. The small-footed myotis (*Myotis ciliolabrum*), long-legged myotis (*Myotis volans*), and western pipistrelle are the most common bats found in the Great Basin vegetation types. The highest species richness of bats on the NTS is found in the Great Basin vegetation types [276].

PROTECTED SPECIES

The desert tortoise (*Gopherus agassizii*) (Figure 28) is the only animal species commonly found on the NTS that is protected under the Endangered Species Act (ESA) of 1973. It is listed as a threatened species. The bald eagle was down-listed in 1995 from an endangered to a threatened species. The peregrine falcon was removed from endangered status in 1999. The mountain plover (*Charadrius montanus*) is proposed for listing as a threatened species. These three birds, however, are uncommon transients to the NTS [139, 264] and are not expected to be impacted by NTS activities. No threatened or endangered plant species are known to occur on the NTS.

Desert Tortoise

The ESA requires that DOE consult with the U.S. Fish and Wildlife Service (FWS) to insure that NTS activities do not jeopardize the continued existence of the threatened desert tortoise or destroy their

Figure 28. Desert tortoise (*Gopherus agassizii*). This is the only animal commonly found on the Nevada Test Site that is protected as a threatened or endangered species under the Endangered Species Act.

critical habitat. To comply, NNSA/NV and the Yucca Mountain Site Characterization Office (YMSCO) conducted consultations and obtained Biological Opinions from the FWS [768, 769]. Both Opinions concluded that proposed activities on the NTS are not likely to jeopardize the continued existence of the Mojave population of the species and that no critical habitat would be destroyed or adversely modified. Terms and conditions listed in the Opinions are followed when activities are conducted within the range of the desert tortoise on the NTS. DOE sponsored numerous studies on the distribution, abundance, and life history of desert tortoises starting in 1981 and continuing through 1996. The vast majority of these studies were funded by YMSCO through their Desert Tortoise Monitoring Program.

Tortoises are found in the southern portion of the NTS. They extend north to the northern edges of Jackass Flat; Frenchman Flat; and the small valleys, Wahmonie Flat and Pluto Valley, that separate them. Tortoises also are found on some slopes just to the north of those valleys, at least in the Calico and CP Hills, but they are rare or not found further north in Topopah Valley, Mid Valley, Yucca Flat, Plutonium Valley, or on the other hills surrounding those valleys [541].

Transect studies conducted from 1981 to 1989 indicate that the abundance of tortoises on the NTS is low (0.4-1.5 tortoise sign/km) to very low (0-0.4 tortoise sign/km) relative to other areas within this species' range [180]. Throughout the Yucca Mountain area, the relative abundance of tortoises is low and tortoise densities are estimated to be from about 4 to 20 tortoises/km^2 [405]. In 1996, NNSA/NV funded transect surveys within ELUs of the NTS which were identified and mapped during vegetation mapping of the NTS (see Flora section of this report). Results of these surveys were used to produce a more accurate map of tortoise abundance for land-use planning[854].

Studies and observations on desert tortoise movement patterns, burrow use, diet, hibernation behavior, survival, and predation were conducted under YMSCO's Desert Tortoise Monitoring Program. These studies are included in this annotated bibliography (see citations with keywords "desert tortoise" and "YMSCO").

Species of Concern

The FWS recognizes that some plant and animal species may have conservation needs and unofficially designates these as "species of concern". They are not protected under the ESA, but federal agencies are encouraged to consider these species when evaluating environmental impacts of their activities.

Over the last three decades, NNSA/NV has taken an active role in collecting information on the status of rare plants on the NTS, which include those currently designated as species of concern. Numerous documents have been produced reporting their occurrence, distribution, and susceptibility to threats on the NTS [36, 87-89, 110, 111, 152, 156, 565-568]. There are currently 11 plant species of concern which are monitored on the NTS [95, 96]. These include *Arctomecon merriamii* (desert bearpoppy) (Figure 29), *Astragalus beatleyae* (Beatley's milkvetch) (Figure 30), *Astragalus funereus* (Funeral Mountain milkvetch), *Astragalus oopherus* var. *clokeyanus* (egg milkvetch), *Camissonia megalantha* (largeflower suncup), *Cymopterus ripleyi* var. *saniculoides* (Ripley's springparsley), *Frasera pahutensis* (Modoc elkweed), *Galium hilendiae* ssp. *kingstonense* (Hilend's bedstraw), *Penstemon pahutensis* (Paiute beardtongue), *Phacelia beatleyae* (Beatley's scorpionweed), and *Phacelia parishii* (Parish's scorpionweed).

There is currently one reptile, nine bird, and seven bat species which occur on the NTS that are unofficially designated as species of concern by the FWS. The one reptile is the chuckwalla (*Sauromalus obesus*). The nine birds are the Western Burrowing Owl (*Athene cunicularia*), Ferruginous Hawk (*Buteo regalis*), Black tern (*Chlidonias niger*), Gray Flycatcher (*Empidonax wrightii*), Peregrine Falcon (*Falco peregrinus*), Western Least Bittern (*Ixobrychus exillis*), Phainopepla (*Phainopepla nitens*), White-faced Ibis (*Plegadis chihi*), Lucy's warbler (*Vermivora luciae*). Of these birds, only the Western Burrowing Owl resides and breeds on the NTS. The seven bats are the Townsend's big-eared bat (*Corynorhinus townsendii*), spotted bat (*Euderma maculatum*), small-footed myotis (*M. ciliolabrum*), long-eared myotis (*M. evotis*), fringed myotis (*M. thysanodes*), long-legged myotis (*M. volans*), Yuma myotis (*M. yumanensis*), and big free-tailed bat (*Nyctinomops macrotis*).

Some investigations into the life history, distribution, and abundance of chuckwallas (Figure 31) have been conducted at the NTS. Chuckwalla habitat is primarily rock outcrops and boulders. They occur on the southern one-third of the NTS. Tanner and Jorgensen [710] reported chuckwalla

Figure 29. ***Arctomecon merriamii*** **(desert bearpoppy). On the Nevada Test Site, this species of concern occurs primarily on limestone and dolomite outcrops of Red Mountain and Mercury Ridge in Areas 5 and 23.** (Photo by Charles Webber, © 1998 California Academy of Sciences)

Figure 30. ***Astragalus beatleyae*** **(Beatley's milkvetch). On the Nevada Test Site, this species of concern occurs in the** ***Pinus monophylla*** **Woodland associations in Areas 18 and 20.** (Photo by Susan Cochrane)

Figure 31. Chuckwalla (*Sauromalus obesus*). This species of concern inhabits rocky outcrops within the southern two-thirds of the Nevada Test Site. (Photo by Phil Medica)

from six locations on the NTS including Red Mountain, Mercury Pass, 2 km northeast of Mercury Pass, CP Hogback Ridge, News Nob, and in Area 1 near the intersection of Pahute Mesa Road and the Tippipah Highway. Tanner [706] conducted mark and recapture of 45 chuckwallas at Mercury Pass during 1965-1971, suggesting they were abundant there. Sanborn [630] collected 16 chuckwallas in the Specter Range in 1966-1967 from Rock Valley and 10 at Mercury Valley Pass in 1971. The northernmost record of chuckwalla at the NTS was reported from Yucca Flat near the intersection of Pahute Mesa Road and Tippipah Highway [710], although no rocky areas were present in this area. News Nob, just north of CP Hills, appears to be the northernmost chuckwalla habitat at the NTS. Systematic spotting surveys and scat surveys to better document chuckwalla distribution were conducted in 1996 [687]. Areas west of Fortymile Wash, the Specter Range near Rock Valley, and the hills around Mercury Pass were found to contain the best habitat for this species on the NTS, and the northern boundary of their distribution on the NTS corresponds roughly with that of the desert tortoise [687]. Currently, no DOE project activities are expected to impact chuckwalla habitat.

The banded gila monster is another reptile unofficially designated by the FWS as a species of concern. A single sighting of a gila monster was reported on the NTS [855]. Because there has only been a single sighting on the NTS, no studies have been planned or conducted to verify its distribution and abundance on the NTS.

The Western Burrowing Owl (Figure 32) is the only bird species of concern which may be significantly affected by activities on the NTS. This ground-dwelling owl uses burrows that are usually dug by other animals or man-made structures. It is found in dry, open areas with flat to gradually sloping terrain in most of the major valleys in the eastern and southern portions of the NTS: Frenchman Flat, Jackass Flats, Mercury Valley, Rock Valley, and Yucca Flat, and around Buckboard Mesa in the west-central portion of the NTS [687, 95]. Most (40) of the 69 known burrows are in the Transition ecoregion of the NTS, 21 are in the Mojave Desert, and 8 are in the Great Basin Desert [95]. Forty-four of the 69 owl burrows found are in disturbed habitat and nearly two-thirds of them are man-made structures (i.e., partially or fully buried pipes and culverts with exposed openings) [687, 95], suggesting that some human activities on the NTS have benefitted this species by providing suitable burrows. Annual monitoring of known burrows from 1998 to 2001 indicates that some owls reside year round in the Transition and Great Basin ecoregions, although the numbers of active burrows on the NTS increase and decrease during spring and fall migration, respectively. Eight breeding pairs of owls and 45 young were detected on the NTS during 2000 [95].

Figure 32. Western Burrowing Owl (*Athene cuniculario*). This is owl is observed year round on the Nevada Test Site, although it is more abundant during the spring and summer. (Photo by Paul Greger)

Prior to the 1990s, little work was done to document bat communities on the NTS. Jorgensen and Hayward [368] opportunistically collected four bat species on the NTS, one of which was the Townsend's big-eared bat (Figure 33), a species of concern. In the early 1990's, bat surveys were conducted in support of ecological programs funded by both YMSCO and NNSA/NV. These surveys [532, 627, 852] documented the presence of an additional seven bat species on the NTS, of which four were species of concern: the spotted bat, long-eared myotis, fringed myotis, and long-legged myotis. In 1996, mist-net surveys at selected water sources on the NTS were initiated to specifically determine the distribution of bat species of concern [687]. During these surveys, the spotted bat was captured for the first time on the NTS, whereas before 1996 this species had only been heard on one occasion over a sump pond in Area 19 on Pahute Mesa [184]. Bat surveys were expanded in 1998 to include acoustic surveys at water sources and potential roost sites (i.e., tunnels, mines) on the NTS as well as mist-net surveys. Acoustic surveys utilize a portable field device which records and analyzes the species-specific, ultrasonic echolocation calls of bats. With both mist-netting and acoustic surveys, three additional bat species of concern have been

Figure 33. The Townsend's big-eared bat (*Corynorhinus townsendii*) is not known to migrate but hibernates in mixed-sex aggregations of a few to many hundred. Nothing is known of its roost and hibernation sites or behavior on the Nevada Test Site. (Photo is from Texas Tech Univ. Water Resources Center web site: [www.wrc.ce.ttu.edu/henrypage/co-to.html, access 07/26/01)](www.wrc.ce.ttu.edu/henrypage/co-to.html)

documented on the NTS: the small-footed myotis [93], the Yuma myotis (O'Farrell, 2001), and the big free-tailed bat [276]. Bat species of concern occur throughout the NTS but most are found in the Great Basin Desert ecoregion. In 1999, acoustic surveys at selected historic mines and DOE-excavated tunnels were initiated to determine their use by bats. These man-made excavations can be used as day and night roosts and sites for maternity colonies and hibernacula. These surveys indicate that at least four bat species of concern use these excavations: small-footed myotis, long-eared myotis, fringed myotis, and long-legged myotis [95].

State-Managed Species

The State Board of Fish and Game Commissioners is empowered to preserve, protect, manage, and restore wildlife, including non-game species, within the state of Nevada. Game animals, fur-bearing animals, game birds, migratory game birds, game fish, and game amphibians are managed through regulated hunting, trapping, and fishing. The State extends special protection to certain species considered to be endangered or rare within Nevada. Species that fall within either of these State-protected classifications and which occur on the NTS include: desert tortoise; gila monster; Lesser Nighthawk; Common Nighthawk; Turkey Vulture; White-faced Ibis; Mourning Dove; Belted Kingfisher; Greater Roadrunner; all hawks, eagles, falcons, and owls; Gambel's Quail; Chukar; White Pelican; prong-horned antelope; bighorn sheep; mule deer; gray fox; kit fox; mountain lion; bobcat; spotted bat; and cottontail rabbits. Hunting of game species is prohibited on the NTS.

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KEYWORD INDEX FOR ANNOTATED BIBLIOGRAPHY

KEYWORD INDEX FOR ANNOTATED BIBLIOGRAPHY

This section presents lists of citations by keywords in order to assist the reader in looking up references related to general topics (e.g., invertebrate studies, ecological studies, NAEG projects). Keywords were assigned based on the content of a citation's annotation alone and not from reading the entire reference, nor were author-assigned keywords from journal articles used.
Table 3 is essential to successfully use this index, as it provides the reader with the criteria by which keywords were assigned to each citation. For example, Table 3 explains that for articles on plants and animals, we used the most specific keyword only. So an article about small mammals has the keyword "mammal" only, but not the keyword "vertebrate". Similarly, an article about the threatened desert tortoise has the keyword "desert tortoise", but not the keyword "reptile".

Table 4 contains citations by funding source of the project or by certain agencies/universities who conducted the investigation. Table 5 lists those citations which are bibliographies or environmental management documents. Table 6 contains citations which reference abiotic components of the NTS, including radionuclides in soil and air. Table 7 contains citations specific to plant and animal species which are, or were, considered rare; to invasive species; and to the unique wetland habitats of the NTS. Table 8 contains citations that refer to general categories of flora and fauna (e.g., reptile, bird). Table 9 contains citations related to types of studies (e.g., ecological, taxonomic, radiation effects studies). A single citation will have multiple entries into Tables 3 through 9 equal to the number of keywords assigned to the citation. Finally, to provide further assistance in searching the literature, Table 10 presents a cross-reference of citations by category of biota as well as by category of ecological investigation. For example, all citations pertaining to taxonomy of NTS invertebrates or to diets of NTS reptiles could be found by using this table.

Table 3. Definitions used in assigning keywords to each citation.

KEYWORD	DEFINITION
Keywords Which Identify Funding Source or Type of Reference	
BYU	Citation pertains to inventories or ecological investigations of native NTS fauna conducted by Brigham Young University from 1959-1966
EPA	Citation pertains to a U.S. Environmental Protection Agency program or investigation
FACE	Citation pertains to research conducted at the Nevada Desert Free Air CO_2 Enrichment facility on the NTS
IBP	Citation pertains to research done as part of the US/IBP Desert Biome Program
NAEG	Citation pertains to a Nevada Applied Ecology Group program or investigation
UCLA	Citation pertains to a University of California, Los Angeles investigation
YMSCO	Citation pertains to Yucca Mountain or to a Yucca Mountain Site Characterization Office project or investigation
Management	Citation contains management policies for the NTS or environmental/ecological assessments that dictate the management of resources on the NTS
Bibliography	Citation is a bibliography of prior published research on the NTS related to ecology
Keywords for Abiotic Features of the Environment	
Climate	Citation references climatic data (e.g., precipitation, temperature, seasonality)
Geology	Citation references geologic information (e.g., geologic strata, geologic processes)
Hydrology	Citation references hydrologic information (e.g., water movement in the environment)
Perturbations	Citation references natural (e.g., fire, flood, storm, drought) or man-induced physical/chemical disturbances (e.g., increased CO_2 levels, craters, dust deposition, denuding, scrapes, borrow areas, ditches, roads)
Soil property	Citation references some soil properties (e.g., moisture, texture, pH, soluble salts, taxonomy)
Radionuclide inventory	Citation references measures of radionuclides in soil or air particulates and abiotic transport processes (excludes radiation contamination levels in biota, doses to biota, and bio-transport processes - see keyword “radiation”)
Keywords for Species/Habitats of Concern	
Desert tortoise	Citation pertains to the desert tortoise (*Gopherus agassizii*)
Invasive species	Citation specifically references non-native plants of the NTS which fall under Executive Order for their control (*Note*: These species may also be included in references with keywords “ vegetation”, “annual plants”, or “perennial plants” but the focus of those citation are not on an invasive species per se)
Sensitive animals	Citation pertains to animals that are protected or are considered species of concern by regulatory agencies
Sensitive plants	Citation pertains to plants that are protected or are considered species of concern by regulatory agencies and to plants that have been or are considered rare on the NTS
Wetlands	Citation references wetlands, seeps, springs, ponds, or natural bodies of water

Table 3. Definitions used in assigning keywords to each citation (Continued).

KEYWORD	DEFINITION
Keywords for Biota	
Microbiota	Citation references microorganisms such as viruses, bacteria, fungi, algae, moss, and lichen
Vegetation	Citation references assemblages of plants such as vegetation types, associations, alliances, and plant communities, or it references vegetation in general
Annual Plants	Citation references one or more vascular plants that are annuals
Perennial Plants	Citation references one or more vascular plants that are perennial
Invertebrate	Citation references one or more invertebrate species (annelids, arthropods, mollusks, and nematodes)
Vertebrate	Citation references vertebrate species and does not indicate if vertebrate species are fish, amphibians, reptiles, birds, or mammals
Fish	Citation references one or more species of fish
Amphibian	Citation references one or more species of amphibian
Bird	Citation references one or more species of birds
Reptile	Citation references one or more species of reptiles but not the desert tortoise (see keyword “desert tortoise”)
Mammal	Citation references one or more species of mammals
Keywords for Categories of Ecological Investigation or Research	
Ecology/ecosystem	Citation references the ecosystem or the relationship of biota to each other and their environment (e.g. species abundance, distribution, competition, predation, biomass, production, succession, cover, species distribution, movement patterns, behavior)
Life History	Citation references life cycle parameters of one or more species (e.g., growth, survival, reproduction, morphology, phenology)
Methods	Citation references experimental methods, techniques, models, or scientific procedures that were being developed or evaluated
Nutrition/diet	Citation references the nutrition or diet of one or more species (e.g., food chains, predation, mineral or radionuclide uptake in plants)
Physiology	Citation references the biochemistry and metabolism of one or more species (e.g., gas exchange, energetics, moisture conservation, hormonal controls, genetics)
Radiation	Citation references radiological investigations related to the fate and effects of radionuclides in the environment and includes bio-transport, bio-availability, exposure, dose, effects, and contamination levels in plants and animals (excludes radionuclide inventories in soil and air - see keyword “radionuclide inventory”)
Revegetation	Citation references efforts to reestablish native vegetation at disturbed sites or studies on revegetated sites
Taxonomy	Citation references the taxonomic description of one or more species, report of a new species, first sightings of a species on the NTS, complete flora/fauna lists for the NTS. (Note: does not include lists of species observed at specific sites on the NTS [i.e. at Yucca Mountain, Cane Springs, etc.)

Table 4. Citations referencing funding sources.

Funding Source	Citation
BYU	15, 18, 21, 28, 29, 60, 97, 99, 100, 130, 155, 201, 241, 253, 286, 289, 368, 371, 381, 474, 701, 703, 709, 710
EPA	40, 108, 131, 134, 246-250, 287, 379, 398-400, 408, 432, 651-664, 666-670, 717, 766
FACE	104, 105, 144, 163, 164, 238, 278, 279, 303, 348-354, 358, 359, 413, 490-494, 511, 521, 522, 633, 674, 676-678, 716, 824, 863-865
IBP	2, 53, 56, 57, 58, 145-148, 165-167, 176-178, 188, 190, 199, 211-216, 231, 338, 340, 342, 344, 346, 347, 415, 438, 454, 479, 598, 619, 650, 680, 681, 730-734, 739, 748-750, 773, 775, 778, 796, 808, 813, 814, 816
NAEG	41, 44-51, 120, 122-126, 149, 169-171, 174, 193, 194, 197, 198, 200, 203-205, 207, 234, 242-244, 282, 304-306, 390, 394, 416, 417, 436, 458-463, 465, 499, 500, 526, 555, 557, 559-561, 564, 583-585, 588, 593, 602, 610, 613, 618, 631, 636, 766, 771, 783, 795, 828, 831-837, 839
UCLA	52, 62-66, 71, 75, 77, 78, 218, 396, 397, 423, 429, 463, 485, 488, 503, 590, 591, 617, 620, 781
YMSCO	37, 109, 112-119, 133, 151, 157-162, 181, 182, 184-186, 195, 237, 256, 258-260, 270, 277, 291-294, 298, 299, 301, 307, 375-377, 401-407, 449, 457, 466-468, 482, 483, 496, 497, 506, 508, 520, 524, 529-534, 536-547, 550, 582, 634, 635, 641, 673, 676, 682-685, 688-694, 769, 843, 847, 862

Table 5. Citations which are bibliographies or environmental management documents.

Bibliographies	Management Documents
149, 159, 193, 194, 200, 203-205, 208, 300, 416, 417, 436, 498, 640, 766, 835	92, 96, 110, 111, 235, 281, 531, 546, 545, 547, 761-763, 767-769, 862

Table 6. Citations referencing abiotic features.

Abiotic Feature	Citation
Climate	23, 55-57, 73, 74, 76, 81-86, 90, 91, 102, 103, 196, 203, 238, 278-280, 293, 294, 302, 310, 315-317, 320, 321, 323-325, 331, 332, 345, 349, 358, 391, 397, 423, 450, 476, 478, 485, 491, 493, 494, 498, 521, 527, 549, 592, 599, 600, 620, 622, 626-628, 632, 649, 675, 676, 678, 683-686, 697, 698, 730-734, 739, 741, 742, 749, 750, 762, 770, 798, 802, 826, 827, 845, 849-851, 855, 858-860
Geology	33, 34, 39, 86, 107, 151, 162, 175, 180, 195, 196, 268, 269, 271-273, 356, 376, 377, 435, 498, 507, 524, 525, 535, 582, 623, 624, 673, 688-696, 721, 762-763, 855, 856, 861
Hydrology	39, 92, 102, 107, 120, 175, 246, 255, 273, 305, 330, 343, 346, 379, 390, 391, 435, 454, 498, 536, 598, 619, 623, 649, 673, 675, 676, 685, 686, 696, 717, 762, 763, 800, 802, 819, 842-845, 847, 861
Perturbations	15, 17, 18, 20, 28, 30, 31, 37, 39, 41, 50, 64, 66-68, 73, 84, 93-95, 104-106, 117, 118, 144, 163, 164, 169, 171, 179, 181, 182, 184-186, 204, 237, 251, 253, 255, 258, 260, 272, 278, 286, 291, 293, 311, 315-328, 330, 332-335, 337, 339, 345, 348-354, 358, 359, 371, 382, 383-385, 387, 403, 413, 421, 428, 440, 442, 450, 453, 457, 485, 490-495, 497, 499, 500, 504, 506, 508, 511, 521, 523, 530, 531, 536, 543, 545, 547, 550, 558, 560, 568, 569, 573, 576, 577, 581, 590, 591, 594, 597, 600, 601, 625-629, 634, 635, 642-645, 647, 648, 652, 674, 677, 678, 703, 721, 722, 725, 735, 743, 744, 761, 762, 767-770, 776, 783, 789, 795, 798, 821-823, 825, 830, 841, 844, 847, 849-853, 862-865
Soil property	2, 19, 36, 37, 65, 86, 92, 101, 104, 105, 109, 173, 176, 177, 187, 191, 195, 199, 210, 211, 213, 239, 305, 310, 330, 336, 338, 340, 341, 344, 357, 380, 390, 391, 398, 399, 400, 454, 484, 485, 491, 498, 507, 520, 522, 535, 536, 580, 589-592, 598, 612, 616, 619, 620, 650, 673, 680, 681, 722, 730, 731, 733, 734, 739, 762, 763, 774, 777, 780, 781, 787, 788, 790, 794-796, 805, 812-814, 818, 819, 821-824, 839, 858-860
Radionuclide inventory	39, 40, 42, 43, 67, 92, 108, 127, 132, 169-171, 174, 193, 194, 197, 198, 200, 203, 207, 234, 235, 244, 252, 254, 257, 304-306, 357, 366, 379, 382-389, 392-397, 408-411, 414, 418, 420, 423, 425, 429, 433, 436, 463, 480, 486, 489, 498, 503, 504, 512-516, 519, 526, 549, 584, 587, 595, 608, 610, 611, 613, 614, 617, 618, 620, 636, 637-639, 648, 664, 762, 764, 765, 831-834, 836, 837, 840

Table 7. Citations referencing biota/habitat of special concern.

Biota/Habitat of Concern	Citation
Desert tortoise	93-95, 112, 114, 116, 119, 133, 137, 157, 160, 161, 180-182, 184, 186, 187, 196, 240, 256, 258, 267, 299, 307, 375, 401-403, 405-407,440, 442, 445' 446, 449, 453, 466-468, 476, 478, 496-497, 506, 529-531, 533, 534, 537-542, 544-547, 710, 747, 761, 763-765, 767-769, 854
Invasive species	30, 64, 68, 73, 80, 85, 86, 124, 131, 138, 164, 286, 293, 312, 313, 315, 318, 319, 322, 326, 329, 331, 332, 339, 344, 346-351, 353, 371, 450, 455, 491, 492, 497, 529, 573, 579, 597, 581, 621, 644, 645, 647, 678, 679, 703, 730-734, 770, 777, 789, 857, 860, 864
Sensitive animals	93-95, 113, 119, 157, 159, 160, 181, 182, 184, 276, 496, 543, 687, 762-765
Sensitive plants	36, 78, 86-89, 93-96, 110, 111, 138, 152, 156-160, 181, 182, 184, 297, 482, 483, 496, 543, 565-568, 762-765
Wetlands	13, 27, 78, 87-89, 93-95, 121, 168, 246, 255, 265, 273, 276, 281, 286, 317, 324, 325, 379, 435, 548, 586, 623, 642, 667, 685, 686, 688-694, 717, 762-765

Table 8. Citations referencing biota.

Keyword	Citation
Microbiota	33, 34, 38, 44-51, 104, 105, 135, 151, 162, 168, 172, 173, 199, 234, 245, 268-273, 275, 281, 289, 290, 301, 304, 306, 338, 340, 376, 377, 406, 407, 479, 498, 507, 524, 525, 536, 582, 624, 628, 633, 642, 646, 650, 686, 688-697, 717, 773, 774, 787, 796, 813, 831-834, 836, 839, 841
Vegetation	2, 4, 6, 7, 10, 13, 14, 18-22, 24, 27-30, 32, 36, 39, 41, 46, 47, 51, 62, 63, 66-68, 75, 77-86, 92-95, 98, 100, 101, 104-106, 120, 121, 127, 131, 134, 148, 159, 160, 169, 170, 181, 195, 198, 199, 203-205, 208, 218, 221, 223, 225, 226, 233, 234, 242-244, 252, 253, 255, 257-260, 274, 277, 280-282, 288, 291-295, 300, 304- 306, 314, 330, 333, 336, 343, 345, 358, 361, 362, 368, 371, 372, 374, 379, 381-383, 386, 388, 390, 392, 393, 395, 397-399, 408-411, 416, 417, 420-422, 424-426, 428-432, 434, 436, 465, 479, 482-485, 487, 488, 490, 495-498, 501, 502, 504-508, 512-516, 518, 519, 540, 543, 550, 555, 557, 575, 576, 580, 583-585, 587, 593-598, 608, 610, 611, 613, 614, 617, 622, 630, 634-639, 649, 675, 676, 683-685, 700, 701, 703, 710, 713, 722-724, 726, 727, 736, 738, 743, 762, 764, 765, 770, 778, 781, 782, 793, 796, 802, 806, 821, 822, 825, 826, 831-834, 836, 837, 841, 848, 853, 862
Annual Plants	30, 49, 64, 65, 68, 70-74, 76, 80, 82, 85, 124, 131, 138, 144, 146, 163, 164, 277, 286, 293, 296, 312, 313, 315, 317-319, 322, 324-326, 328, 329, 331, 332, 339, 342, 344, 346-351, 353, 371, 396, 433, 450, 455, 481, 491-493, 497, 501, 520, 529, 556, 559, 560, 573, 577-579, 581, 597, 602-607, 615, 618, 619, 621, 643-645, 647, 677-680, 703, 716, 730-734, 739, 742, 744, 776, 777, 780, 783, 789, 791, 805, 807, 852, 855, 857, 860, 864
Perennial Plants	1, 3, 12, 15, 30, 37, 48, 52-58, 66, 67, 69, 76, 81, 82, 84, 85, 90, 91, 106, 109, 124, 128, 131, 132, 138, 144, 146, 163-167, 182-191, 212-216, 237-239, 277-280, 303, 308-311, 316, 317, 320, 321, 323-325, 327, 328, 332, 334, 335, 337-342, 344, 346, 347, 352, 354, 359, 371-373, 378, 380, 391, 399, 413, 427, 450, 456, 464, 481, 491-494, 499-501, 511, 520-523, 528, 529, 536, 548, 551-554, 556, 558-564, 569-572, 575, 578, 579, 581, 588-592, 598-602, 606, 612, 616-620, 633-635, 643-645, 647, 673, 674, 677-681, 683, 698, 703, 721, 730-734, 738, 739, 741, 742, 744, 771, 772, 775, 776, 778, 779, 783-788, 790-792, 794, 797-801, 803-805, 808-819, 824, 826, 827, 838, 842-847, 852, 855, 857-860, 863-865

Table 8. Citations referencing biota (Continued).

Keyword	Citation
Invertebrates	5-18, 21-30, 32, 60, 61, 97-101, 103, 116, 129, 130, 140-144, 153-155, 176-178, 182, 184, 201, 209-216, 218, 236, 241, 251, 253, 255, 257, 281, 283, 289, 300, 355, 361, 363, 366, 381, 386, 415-417, 436, 438, 456, 473-475, 498, 510, 512-516, 543, 622, 686, 700-704, 709, 713, 715, 724-726, 730-734, 739, 744, 762, 770, 820, 846, 855
Vertebrates	18, 28, 29, 31, 39, 41, 125, 159, 160, 169-171, 195, 198, 203, 217, 219, 205, 225, 234, 243, 246, 247, 249, 257, 260, 282, 300, 304, 386, 388, 392, 394, 395, 408, 410-412, 416, 417, 420, 425, 436, 459, 461, 463, 496, 502, 506, 512-516, 526, 543, 584, 586, 597, 622, 652, 670, 724, 762, 764, 765, 770, 828, 831-834, 836, 837, 862
Fish	121, 139, 379, 498
Reptiles	17, 22, 99, 101, 115, 117, 119, 121-123, 126, 184, 186, 218, 223, 281, 296, 317, 324, 325, 328, 332, 345, 369, 370, 372, 439, 440, 442-444, 447, 448, 450-453, 458, 460, 462, 477, 498, 499, 517, 630, 665, 687, 705-715, 725, 726, 728-735, 737, 739, 740, 745, 746, 748-750, 752, 754-760, 776, 806, 849-853, 855
Birds	92-95, 99, 101, 113, 121-122, 139, 170, 182, 184-186, 192, 261, 262, 264, 265, 281, 286, 295, 298, 317, 324, 325, 328, 345, 403, 404, 458, 498, 573, 574, 576, 641, 654, 658, 663, 688, 726, 730, 731, 733, 734, 739, 746, 852, 853, 855
Mammals	5-7, 9, 18-20, 25, 26, 30, 35, 40, 43, 59, 74, 84, 85, 92-95, 99-101, 118, 121-126, 136, 145-148, 157, 165-167, 170, 179, 181, 182, 184-186, 192-194, 202, 206, 217-233, 236, 244, 248, 250, 253-255, 257, 259, 261-266, 274-276, 280, 281, 284, 285, 287, 289, 305, 306, 308, 309, 317, 324, 325, 328, 332, 334, 335, 345, 360, 362, 364, 365, 367, 368, 371, 378, 379, 382, 383, 386, 393, 409, 414, 418, 419, 422, 426, 427, 429-433, 437, 440, 441, 450, 458-460, 462, 469-472, 480, 481, 495, 497-500, 509, 510, 518, 519, 532, 592, 595, 608, 617, 621, 625-629, 631, 648, 651, 653-664, 666-672, 679-683, 685, 687, 699, 178-720, 726, 727, 730-734, 736, 738, 739, 746, 751, 753, 776, 802, 806, 826, 829, 830, 840, 846, 852, 853, 855

Table 9. Citations referencing various types of investigations or research.

Keyword	Citation
Ecology/ecosystem	2, 5-10, 12-15, 17-29, 32, 35-39, 41, 48-51, 55, 57, 58, 60, 62-64, 66-70, 73-75, 77, 80-91, 93-95, 97, 98, 100, 101, 103, 106, 110, 111, 113, 116-120, 121-124, 130, 131, 133, 134, 136-138, 144, 145, 147, 148, 151, 152, 155-161, 163-167, 172, 173, 176-182, 184-190, 193-196, 200, 202, 203, 208-216, 230, 231, 234, 237, 239-241, 246, 250, 251, 253, 256, 258-271, 276, 277, 280, 281, 284, 286, 289, 291-294, 298, 299, 302, 303, 305-309, 311-329, 331, 332, 334, 335, 336, 339, 341-343, 345-355, 362, 364-370, 372, 375, 376, 377, 381, 390, 391, 403-407, 415-417, 436-438, 440-442, 445, 447, 448, 449, 450, 454, 456, 458, 466, 473-475, 479, 481, 490, 491, 496-498, 501, 505-507, 512-516, 520, 530-533, 536-547, 550, 555, 557, 565-568, 573-579, 581, 584, 586, 589, 612, 613, 616-622, 624-629, 633, 635, 640, 641, 644, 647, 649, 650, 665, 668, 670-672, 674-678, 680-686, 687-698, 701, 703, 705, 708-713-715, 717, 722-724, 730-735, 739, 742, 743, 746, 748-750, 755-759, 761, 762, 767-770, 772-774, 776, 778, 782, 785, 787, 791, 793, 794, 798-800, 802, 803, 816, 818, 825-827, 829, 830-834, 846, 849, 850, 854-856, 861-865
Life History	1-3, 22, 23, 36, 65, 70-72, 74, 76, 81, 82, 94, 95, 97, 100, 103, 109, 111, 114, 119, 138, 145, 147, 148, 153, 154, 162-164, 217-219, 223-225, 228, 229, 233, 266, 267, 277, 284, 295, 296, 308, 315-317, 320, 321, 323-325, 327, 328, 331, 334, 342, 346-351, 353, 358, 361, 365, 373, 378, 401, 402, 407, 437, 438, 443, 444, 446, 448, 451, 453, 467, 468, 491, 530, 531, 534, 545, 547, 578, 592, 599, 600, 625-629, 634, 641, 663, 665, 699, 701, 703, 706, 709-713, 715, 729, 740-745, 747-750, 752, 755-760, 772, 778, 785, 786, 790, 791, 793, 808
Methods	34, 44, 46, 50, 51, 102, 108, 112, 120, 136, 169-171, 176, 188, 203, 204, 207, 210, 211, 227, 231, 235, 242, 248, 269, 271, 272, 274, 276, 280, 282, 292, 305, 330, 358, 366, 370, 388, 389, 391, 412-414, 426, 430-432, 435, 448, 461, 462, 466, 486, 504, 520, 522, 523, 530, 538, 555, 557, 580, 585, 590, 631, 641, 648, 649, 671, 694-696, 727, 736, 738, 741, 748, 756, 824, 828, 829, 831-834, 836, 837, 841, 848
Nutrition/diet	4, 33, 34, 116, 162, 165-167, 187, 196, 199, 206, 208, 212-216, 221, 223-226, 233, 267, 270, 274, 284, 286, 288, 296, 306, 309, 335, 336, 338, 340-342, 344, 347, 351, 353, 376, 377, 403, 422, 425, 426, 430-433, 455, 456, 481, 484, 487, 488, 529, 573, 583, 584, 587, 595, 596, 598, 602-610, 612, 615-620, 624, 630, 633, 636, 654-670, 679, 697, 709, 711-713, 715, 726, 727, 736, 738, 778, 780, 782, 784, 787, 788, 793, 794, 796, 801, 802, 804-807, 811, 812-815, 817, 831-834, 836, 837, 839, 848, 857, 860

Table 9. Citations referencing various types of investigations or research (Continued).

Keyword	Citation
Physiology	31, 44-47, 53-57, 59, 123, 125, 128, 210, 211, 215, 221, 225, 238, 267, 268, 272, 274, 275, 278, 279, 287, 289, 310, 340, 344, 348-352, 354, 358, 359, 380, 413, 452, 460, 462, 464, 469-472, 476-478, 491-494, 509, 511, 517, 521, 522, 525, 536, 589, 592, 598, 624, 633, 650, 673-678, 716, 718-720, 746, 771, 775, 777-780, 782, 786, 790, 792-794, 797, 808-810, 812, 816, 824, 836, 858-860, 864
Radiation	4, 9, 15, 18, 31, 39-41, 43-52, 66, 67, 70, 92, 100, 122-128, 132, 157, 170, 172, 179, 183, 192-194, 200, 201, 203, 205, 206, 208, 217-226, 228, 229, 232, 233-235, 242, 244, 247, 249, 251-254, 257, 274, 275, 282, 285, 288, 290, 300, 301, 304-306, 366, 371, 373, 374, 379, 382, 383, 386, 388, 392-397, 400, 408-412, 414, 416-422, 424-434, 436, 439, 451, 455, 458-463, 465, 477, 480, 486-489, 495, 500, 502, 509, 512-519, 523-526, 528, 549, 556, 559-564, 569-572, 576, 578, 581, 583-585, 587, 588, 593, 595, 596, 602-608, 610, 611, 613-615, 617, 618, 631, 636-639, 642-647, 651-664, 666-670, 717-720, 725-728, 735-738, 740, 745, 751, 753, 754, 758, 760, 762, 764, 765, 771, 772, 781, 782, 789, 793, 806, 807, 815, 828, 831-834, 836, 837, 839-841, 848, 862
Revegetation	38, 109, 182, 185, 186, 204, 234, 258, 326, 327, 334, 457, 490, 506, 508, 520, 550, 590-592, 594, 597, 601, 722, 778, 781, 783, 784, 795, 798, 819, 821, 822, 831, 836, 838, 841-845, 847
Taxonomy	10-14, 16, 23-29, 32, 48, 60-63, 69, 75, 77-80, 86-89, 97-100, 110, 115, 121, 129, 130, 134, 135, 139-143, 152-155, 168, 172, 201, 236, 241, 245, 283, 286, 297, 363, 366-368, 381, 447, 473, 474, 482, 483, 498, 507, 510, 548, 551-554, 582, 642, 686, 688-695, 700-708, 710, 717, 820

Table 10. Citations cross-referencing categories of ecological investigation with categories of biota

BIOTA CATEGORY	CATEGORY OF ECOLOGICAL INVESTIGATION	
	Ecology/Ecosystem	**Life History**
Microbiota	38, 48-50, 151, 172, 173, 268-273, 281, 376, 377, 479, 498, 507, 624, 628, 633, 650, 688-697, 717, 773, 774, 787	162
Vegetation	2, 28, 39, 41, 62, 63, 75, 77, 83, 86, 93-95, 101, 104, 405, 120, 121, 134, 148, 181, 182, 195, 258, 260, 280, 281, 291-294, 314, 336, 343, 390, 416, 417, 490, 496- 498, 501, 505-507, 512-516, 543, 550, 555, 557, 575, 584, 613, 617, 622, 635, 644, 649, 675, 676, 683-685, 722-724, 743, 770, 778, 782, 793, 802, 826, 862	2, 358, 743
Sensitive Plants	36, 87-89, 93-95, 110, 111, 113, 152, 156, 158, 181, 182, 184-186, 258, 496, 543, 565-568	36, 111
Invasive Species	64, 68, 73, 80, 312, 313, 318, 319, 322, 326, 329, 497, 579, 581, 621, 678, 730-734, 770, 864	348-351, 353
Annual Plants	70, 73, 82, 131, 138, 146, 163, 164, 277, 318, 319, 322, 326, 331, 342, 329, 346, 347, 481, 497, 520, 578, 579, 581, 619, 621, 645, 647, 677, 678, 680, 698, 730-734, 739, 742, 776, 791, 852, 853, 855, 864	65, 70-72, 76, 82, 138, 163, 164, 277, 331, 346, 348, 349, 578, 742, 744
Perennial Plants	37, 55, 57, 58, 69, 81, 82, 90, 91, 106, 131, 146, 163, 164, 188-191, 237, 239, 277, 280, 303, 308, 311, 316, 320, 321, 323, 327, 335, 339, 341, 342, 346, 391, 481, 520, 536, 575, 578, 579, 581, 589, 612, 616, 618-620, 634, 635, 645, 647, 674, 677, 680, 681, 698, 730-734, 739, 742, 772, 776, 785, 787, 791, 794, 798-800, 803, 816, 818, 827, 838, 846, 852, 853, 855, 863, 865	1, 3, 76, 81, 82, 109, 163, 164, 277, 308, 315, 316, 320, 321, 323, 327, 342, 346, 347, 373, 578, 592, 599, 600, 741, 742, 744, 772, 778, 785, 786, 790, 791, 808, 838
Invertebrates	5-10, 12-15, 17, 21-29, 32, 60, 97, 98, 100, 101, 103, 130, 144, 155, 176-178, 209-216, 241, 251, 253, 281, 289, 355, 361, 366, 381, 415-417, 438, 456, 473-475, 498, 543, 622, 686, 701, 703, 724, 730-734, 739, 770, 846, 855	22, 23, 28, 97, 98, 103, 153, 154, 361, 438, 701, 703, 744
Vertebrates	28, 29, 31, 39, 41, 195, 246, 260, 416, 417, 496, 506, 512-516, 543, 584, 586, 622, 724, 770, 862	28
Sensitive Animals	93-95, 181, 182, 184-186, 258, 276, 496, 532, 543, 687	
Fish/Amphibians	121, 498	
Reptiles	101, 117, 119, 121, 122, 369, 370, 372, 440, 442, 447, 448, 458, 498, 665, 687, 705, 708-715, 730-735, 739, 746, 748-750, 755-759, 776, 849-853, 855	119, 295, 443, 444, 448, 451, 665, 706, 709-713, 715, 728, 729, 740, 745, 748-750, 752, 755-760
Tortoise	116, 119, 133, 137, 157, 161, 180-182, 184-186, 196, 240, 256, 267, 299, 307, 375, 405-407, 440, 445, 449, 466, 496, 497, 506, 530, 531, 533, 537-542, 544-547, 710, 761, 767-769, 854	112, 119, 267, 401, 402, 407, 442, 446, 467, 468, 530, 531, 534, 545, 547, 747
Birds	93-95, 101, 113, 121, 122, 182, 184-186, 258, 261, 262, 264, 265, 281, 286, 298, 403, 404, 458, 498, 573, 574, 576, 641, 687, 730-734, 739, 852, 853, 855	295, 641
Mammals	19, 20, 35, 74, 84, 85, 93-95, 101, 118, 121, 122, 124, 136, 145-148, 157, 165-167, 179, 181, 182, 184-186, 202, 227, 230, 231, 250, 258, 259, 261-266, 276, 281, 284, 309, 335, 360, 362, 364, 365, 367, 368, 378, 437, 440, 441, 458, 481, 497, 498, 532, 621, 625-629, 663, 666-668, 670-672, 680-682, 687, 730-734, 739, 776, 829, 830, 846, 852, 853, 855	20, 74, 145, 147, 148, 228, 229, 233, 266, 284, 365, 625-629, 699

Table 10. Citations cross-referencing categories of ecological investigation with categories of biota (Continued)

BIOTA CATEGORY	CATEGORY OF ECOLOGICAL INVESTIGATION		
	Nutrition/Diet	Physiology	Taxonomy
Microbiota	33, 34, 162, 199, 270, 338, 376, 377, 697, 796, 813, 839	44-47, 268, 272, 525, 624, 633, 650	48, 135, 168, 172, 245, 498, 582, 642, 688-695, 717
Vegetation	4, 199, 208, 288, 336, 432, 484, 487, 488, 583, 584, 587, 595, 596, 598, 608-610, 636, 778, 782, 793, 796, 802, 806, 848	358, 413, 675, 676, 778, 782, 793	62, 63, 75, 77-79, 86, 134, 482, 483, 498, 507
Sensitive Plants			78, 87-89, 110, 152, 297, 482, 483
Invasive Species	351, 353, 455, 860	348-351, 491, 492, 777, 864	80
Annual Plants	344, 433, 455, 602-607, 615, 619, 780, 805, 807, 857, 860, 864	344, 348, 349, 491-493, 677, 678, 716, 777, 780, 864	
Perennial Plants	187, 338, 340-342, 344, 347, 602, 606, 612, 616-620, 633, 784, 787, 788, 794, 801, 804, 805, 811-815, 817, 857, 860	53-57, 128, 238, 278, 279, 310, 340, 344, 352, 354, 359, 380, 464, 491-494, 511, 521-523, 536, 589, 592, 598, 673, 674, 677, 771, 775, 779, 786, 790, 792-794, 797, 808-810, 812, 816, 824, 858, 859	69, 548, 551-554
Invertebrates	116, 212-216, 456	210, 211, 215	10-14, 16, 23-25, 28, 29, 32, 60, 61, 97-100, 129, 130, 140-143, 153-155, 201, 236, 241, 283, 363, 366, 381, 473, 474, 498, 510, 686, 700-704, 820
Vertebrates	548	31	28, 29, 724
Fish/Amphibians			121, 139, 498
Reptiles	295, 630, 665, 709, 711-713, 715, 806	452, 477, 517, 746	28, 99, 115, 121, 447, 498, 705-708, 710
Tortoise	196, 267, 529	267, 406, 407, 476, 478	
Birds	286, 403, 573, 657, 658		28, 99, 121, 139, 286, 498
Mammals	165-167, 206, 221, 226, 274, 284, 309, 335, 378, 431, 432, 481, 654-664, 666-670, 679, 726, 727, 736, 738, 806	59, 123, 125, 221, 274, 275, 287, 460, 469-472, 509, 653, 718-720	28, 99, 121, 367, 368, 498

Table 10. Citations cross-referencing categories of ecological investigation with categories of biota (Continued)

BIOTA CATEGORY	CATEGORY OF ECOLOGICAL INVESTIGATION	
	Perturbations	**Radiation**
Microbiota	38, 50, 104, 105, 272, 642	44-49, 172, 290, 301, 524, 525, 642, 646, 717, 839
Vegetation	28, 39, 41, 104-106, 405, 159, 160, 169, 152, 260, 291, 293, 330, 333, 358, 371, 382, 383, 413, 421, 428, 485, 490, 495, 497, 504, 506, 508, 543, 550, 576, 594, 597, 634, 635, 644, 676, 677, 722, 743, 770, 795, 821, 822, 825, 841, 862	4, 39, 41, 46, 51, 92, 127, 208, 218, 223, 225, 233, 234, 242, 244, 252, 257, 282, 288, 300, 304, 371, 374, 382, 383, 386, 388, 392, 393, 395, 397, 408-411, 416, 417, 420-422, 424-426, 428-430, 431, 432, 434, 436, 465, 487, 488, 495, 502, 512-516, 518, 519, 576, 583-585, 587, 593, 595, 596, 608-611, 613, 614, 636-639, 726, 727, 736, 738, 764, 765, 781, 782, 793, 848
Sensitive Plants	568	
Invasive Species	64, 68, 73, 286, 318, 319, 322, 326, 343, 348-351, 353, 450, 491, 492, 573, 581, 645, 647, 678, 789	455, 581, 645, 647, 789
Annual Plants	73, 163, 164, 315, 318, 319, 322, 326, 336, 348, 349, 450, 491-493, 497, 560, 573, 577, 581, 645, 647, 716, 744, 776, 783, 789, 852, 853, 864	70, 396, 433, 455, 556, 559, 560, 577, 578, 581, 602-607, 615, 643, 645, 789
Perennial Plants	37, 66, 67, 106, 163, 164, 237, 238, 278, 279, 303, 311, 316, 320, 321, 323, 327, 334, 335, 337, 339, 345, 352, 354, 359, 450, 491-494, 499, 511, 521, 523, 536, 558, 560, 569, 581, 590, 591, 600, 601, 634, 635, 643-645, 647, 674, 721, 744, 776, 783, 798, 844, 847, 852, 853, 863-865	52, 66, 67, 128, 132, 183, 373, 427, 528, 556, 559-564, 569-572, 578, 581, 588, 602, 606, 617, 618, 643, 645, 647, 738, 771, 772, 793
Invertebrates	15, 17, 18, 30, 144, 251, 253, 543, 703, 744	9, 201, 218, 251, 257, 300, 366, 386, 416, 417, 436
Vertebrates	18, 31, 39, 41, 159, 160, 169, 171, 260, 506, 543, 648, 652, 862	18, 31, 39, 4, 125, 217, 219, 225, 234, 247, 249, 257, 282, 300, 304, 386, 388, 392, 394, 395, 408, 410-412, 416, 417, 420, 425, 436, 459, 461, 463, 502, 512-516, 526, 764, 765, 828
Fish/Amphibians		379
Reptiles	117, 345, 440, 442, 450, 453, 499, 725, 735, 745, 776, 849-853	122, 123, 126, 218, 223, 439, 451, 458, 460, 462, 477, 517, 725, 728, 735, 737, 740, 754, 758, 760, 806
Tortoise	93-95, 181, 182, 184-186, 258, 453, 530, 531, 545, 547, 761, 767-769	
Birds	151, 286, 345, 403, 573, 576, 852, 853	92, 192, 458, 654, 657, 658, 663
Mammals	18, 20, 30, 84, 118, 179, 345, 371, 382, 383, 440, 450, 495, 499, 500, 625-629, 776, 830, 852, 853	18, 40, 43, 92, 122, 123, 125, 126, 157, 179, 192, 206, 217-226, 228, 229, 232, 233, 244, 254, 274, 275, 285, 371, 379, 382, 383, 393, 409, 414, 418, 419, 426, 427, 429, 430-432, 512-516, 727, 736, 738, 751, 753, 840

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Key to Abbreviations

AEC	U.S. Atomic Energy Commission (became U.S. Energy Research and Development Administration: now U.S. Department of Energy, National Nuclear Security Administration)
BNWL	Battelle, Pacific Northwest Laboratories
CEX	Civil Effects Experiment (precedes number assigned by Civil Effects Test Operations, ERDA)
CIC	Coordination and Information Center
Comp.	Compiler
CONF	Conference (precedes number assigned to conference documents by the Technical Information Center)
COO	Chicago Operations Office, ERDA
DOE	U.S. Department of Energy
DOE/NV	U.S. Department of Energy, Nevada Operations Office
DOE/YMSCO	U.S. Department of Energy, Yucca Mountain Project Site Characterization Office
Ed	Editor
EG&G	Edgerton, Germeshausen, and Grier, Inc.
EGG	Edgerton, Germeshausen, and Grier, Inc.
EPA	U.S. Environmental Protection Agency
ERDA	United States Energy Research and Development Administration (now United States Department of Energy National Nuclear Security Administration)
ERLTM-ARL	Environmental Research Laboratories Technical Memorandum, Air Resources Laboratory - Las Vegas, U. S. Dept. of Commerce
FACE	Free Air Carbon Dioxide Enrichment
HW	Hanford Works (formerly General Electric; now several contractors)
IAEA	International Atomic Energy Agency
IBP	International Biological Program
LA	Los Alamos Scientific Laboratory, University of California (as a prefix to a document number)
NAEG	Nevada Applied Ecology Group
NAEIC	Nevada Applied Ecology Information Center
NERC-LV	National Environmental Research Center- Las Vegas (became Environmental Monitoring and Support Laboratory, EPA)
No.	Number
NTIS	National Technical Information Service
NTS	Nevada Test Site
NVO	Nevada Operations Office
ORNL	Oak Ridge National Laboratory
PNE	Peaceful Uses for Nuclear Explosives (was part of ERDA's Plowshare program)
pp.	Pages

Rev.	Revision
SAN	San Francisco Operations Office, ERDA
SAND	Sandia National Laboratories
SF	San Francisco
SM	Precedes document number assigned by International Atomic Energy Agency
SWRHL	Southwestern Radiological Health Laboratory (became Environmental Monitoring and Support Laboratory, EPA)
TIC	Technical Information Center
TID	Precedes document number assigned by Technical Information Center
UC	Unclassified
UCLA	University of California, Los Angeles
UCRL	University of California Radiation Laboratory (now University of California Lawrence Livermore Laboratory)
USAEC	United States Atomic Energy Commission
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
USNC/IBP	U.S. National Council, International Biological Program
Vol.	Volume
WASH	ERDA Headquarters, Washington, D.C.
WT	Weapons Tests (joint project of ERDA and the U.S. Department of Defense)
YMSCO	Yucca Mountain Site Characterization Office

1 **ACKERMAN, T.L. 1979. Germination and Survival of Perennial Plant Species in the Mojave Desert. Southwestern Naturalist 24(3):399-408.**

Germination and survival of 11 perennial plant species were documented in an undisturbed shrub community in southern Nevada. Only one seedling (0.5%) of 201 germinating between 1971 and 1975 survived until the spring of 1977. *Larrea tridentata* and *Ambrosia dumosa* germinated after rains of 25 mm between mid-June and September. *Atriplex confertifolia, Ceratoides lanata, Ephedra nevadensis, Grayia spinosa*, and five other species germinated between October and March after rains of 16 mm. (Author) *Keywords:* perennial plants*, life history*

2 **ACKERMAN, T.L., and S.A. BAMBERG. 1974. Phenological Studies in the Mojave Desert at Rock Valley (Nevada Test Site). In: Lieth, H. (Ed.), Phenology and Seasonality Modeling. Springer-Verlag, New York, pp. 215-226.**

This chapter describes phenological and environmental data collected at Rock Valley in 1971. In 1971 Rock Valley was set up as a validation site as a part of the IBP Desert Biome effort. Rainfall, soil moisture, air temperature, and soil temperature data are related to annual plant biomass and phenology. (CAW) *Keywords:* IBP*, climate*, soil property*, vegetation*, ecology/ecosystem*, life history*

3 **ACKERMAN, T.L., E.M. ROMNEY, A. WALLACE, and J.E. KINNEAR. 1980. Phenology of Desert Shrubs in Southern Nye County, Nevada. Great Basin Naturalist Memoirs 4:4-23.**

This study was done to document the variability in time of phenological events at different locations on the Nevada Test Site. Phenological events for desert shrubs were recorded, and rainfall and temperature data were gathered for four to six years at eight sites that are located within the northern Mojave Desert, the southern Great Basin Desert, and the transitional zone between them. Results have been graphically displayed to show the variability in phenological activity encountered during the study periods and also to show the general correlations between these events and the environmental regime that triggered a particular phenological stage among different species. For a given location a four-to-six-week range in beginning events from year to year was common. In addition to the usual spring activity that normally followed winter rain and snow, most shrub species resumed new growth, and six species were observed to flower and fruit following rare summer or early fall rains. In comparison to surrounding locations, the closed drainage basins within the study area have lower temperatures at night that result in a delay of phenological events in most shrubs. (Authors) *Keywords:* climate*, perennial plants*, life history*

4 **ADRIANO, D.C., A. WALLACE, and E.M. ROMNEY. 1980. Uptake of Transuranic Nuclides from Soil by Plants Grown Under Controlled Environmental Conditions. DOE/TIC-22800, CIC 0083229, Pennsylvania State University, 25 pp.**

Plant uptake of transuranic nuclides ranges through several orders of magnitude, depending on plant, environmental, and edaphic conditions, Most information presently available concerns root uptake of plutonium and americium. In environments where resuspension prevails, direct deposition on plant foliage may exceed root uptake. Atmospheric deposition is generally short-lived, however, and the long-term assessment precludes that root uptake as in the case of surface land contamination and shallow burial of nuclear waste will exceed that obtained from atmospheric deposition. Concentration ratios for ^{241}Am uptake generally ranged from 10^4 to 10^3. Information for curium and neptunium is scarce, but the range appeared to vary from 10^4 to 10^3 and from 10^2 to 10^1 respectively, for these radionuclides. Studies conducted using soils in pot culture showed that ^{241}Am uptake by crops from southeastern U.S. soils was influenced by clay content and low cation exchange capacity. Lime amendment suppressed ^{241}Am uptake, whereas organic matter amendment appeared to temporarily reduce uptake from these soils. Commonly used agricultural amendments generally were ineffective in altering ^{241}Am and ^{239}Pu uptake from western U.S. desert soils. However, the chelate diethylemetramine pentacetic acid markedly and consistently increased root uptake of both plutonium and americium by plants. Chelators and other chemical compounds that enhance complexation reaction with transuranic elements appeared to be most effective in enhancing root uptake from soils. Such compounds, which are usually are present in shallow-burial waste-storage areas, may accelerate plant uptake through deep-penetrating root systems. Numerous studies on the root uptake and translocation of the transuranic elements have been conducted which contributed to the understanding of some aspects of the processes involved. Many investigators have demonstrated that transuranic elements entered plant roots in trace quantities and were transported to aerial parts of plants (Jacobson and Overstreet, 1948; Cline, 1968; Newbould, 1963; Newbould and Mercer, 1961; Rediske and Selders, 1954; Romney, Mork and Larson, 1970; Romney and Price, 1959; Wilson and Cline, 1966; Rediske, Cline, and Selders, 1955). Adams et al. (1975) found that the availability of plutonium to plants was very low from 100-µm $^{238}PuO_2$ particles [concentration ratio (CR) or 10^8 to 10^7 in ash]. In general, they found that plant species differed in uptake, with about 25 times more ^{241}Am taken up than ^{239}Pu. Bean seeds contained 200 times less plutonium than bean leaves, but radish roots contained 10 times as much ^{239}Pu as did the tops. Peeling the radish roots, however, removed 99% of the radionuclide indicating that this radionuclide was mostly contained in or on the peel. (Authors) *Keywords:* vegetation*, nutrition/diet*, radiation*

5 **ALLRED, D.M. 1962. Mites on grasshopper mice at the Nevada atomic test site. Great Basin Naturalist Memoirs 22:101-104.**

Grasshopper mice, *Onychomys torridus longicaudus* were examined for ectoparasites. Approximately the same percentage of mice was infested in one community as in another. Relatively more mice were infested during June and October than in other months, although the average number of mites found on the mice were highest in August and December. The peak in December was due to heavy infestation of chiggers and to mesostigmatids in August. Of the twelve mite species found on this mouse at the Nevada Test Site, *Haemolaelaps glasgowi* and *Ischyropoda armatus* were the most frequent in occurrence. Greatest numbers of individuals belonged to *Ischyropoda armatus*, *Odontacarus linsdalei*, *Euschongastia criceticola*, and an undescribed species of chigger mites. (HP) *Keywords*: invertebrate*, mammal*, ecology/ecosystem*

6 **ALLRED, D.M. 1962. Mites on squirrels at the Nevada atomic test site. Journal of Parasitology 48:817.**

White-tailed antelope squirrels, *Ammospermophilus leucurus leucurus*, were examined for ectoparasites. Although they were commonly infested with lice, fleas, ticks, mites were found on only 10 percent of the squirrels. The predominant species of mite found was *Haemolaelaps glasgowi*. These mites were found in about equal numbers in the major plant communities of the test site. Other mites found were one specimen of a chigger, *Euschongastia* sp. and nine of the family *Dermanyssidae*. There apparently are few mites on squirrels at the Nevada Test Site, although several species, especially the chiggers, are found abundantly on other rodent species living in close association with the squirrels. (HP) *Keywords:* invertebrate*, mammal*, vegetation*, ecology/ecosystem*

7 **ALLRED, D.M. 1963. Mites from pocket mice at the Nevada Test Site (Acarina). Proceedings of the Entomological Society of Washington 65:231-233.**

Totals of 156 *Perognathus formosus*, 473 *Perognathus longimembris* and 23 *Perognathus parvus* were examined for mites from 1959-1962. They were collected from most of the major plant communities. Percentages of mice infested with representatives of 14 species of mites were 30 percent of the *P. formosus* 16 percent of *P. longimembris* and 43 percent of *P. parvus*. The mites found most commonly on pocket mice at the NTS were mesostigmatids of the species *Haemolaelaps glasgowi* and *Hirstionyssus hilli*, and the chiggers *Euschongastia criceticola* and *Trombicula arenicola*. (HP) *Keywords:* invertebrate*, mammal*, vegetation*, ecology/ecosystem*

8 **ALLRED, D.M. 1965. Note of phalangids at the Nevada Test Site. Great Basin Naturalist Memoirs 25:37-38.**

Eurybunus riversi was found widely distributed geographically at the test site. They are present in all the plant communities. Their seasonal activity is predominantly during the winter months. *Leiobunum townsendi* is a common species in the western United States, but at the test site only four specimens were found. These were taken in a Pinyon-Juniper community during July and August. This species is likely more typical of the higher and more northern communities than of the Lower Sonoran and Mohave areas. (HP) *Keywords:* invertebrate*, ecology/ecosystem*

9 **ALLRED, D.M. 1967. Ecological consideration of nuclear detonations and Acarina related to zoonoses. In: Proceedings of the Second International Congress of Acarology (CONF-670703-1), pp. 627-629.**

Studies of the ecology of animals at the Nevada Test Site are reported. Ectoparasites were more numerous on rodents living adjacent to buried nuclear waste than on those living in areas of normal background radiation. Factors determining the maintenance and spread of zoonoses are discussed. It is pointed out that immunity of animals to infestation by ectoparasites may be affected either adversely or favorably by inhabitation of irradiated areas. (HLW) *Keywords:* invertebrate*, mammal*, ecology/ecosystem*, radiation*

10 **ALLRED, D.M. 1969. Bees of the Nevada Test Site. Great Basin Naturalist Memoirs 29:2024.**

Between 1959 and 1965, bees representing 71 species of 35 genera were collected from plants of more than 40 species at the

Nevada Test Site. Bees of nine of the species are new to science, and six others possibly are new. Most specimens were taken during June and July, but some were found as early as March and others as late as September. Bees of greatest abundance, as indicated by those collected, were *Dialictus albohirtus*, *Tetralonia* n. sp. "pr," *Anthophora urbana*, and *Centris rhodopus*. Those with the widest geographic distribution at the test site were *Diatictus hyalinus*, *D. albohirtus*, and *Anthophora urbana*. The species found on the greatest variety of plants was *Dialictus albohirtus*. A greater variety of bees was found on *Stanleya pinnata*, *Asclepias erosa*, and *Petradoria pumila* than on other plants. (Author) *Keywords:* vegetation*, invertebrate*, ecology/ecosystem*, taxonomy*

11 **ALLRED, D.M. 1969. Lepidoptera of the Nevada Test Site. Great Basin Naturalist Memoirs 29:42.**

Moths and butterflies of the Nevada Test Site are identified both generally and specifically and alphabetically arranged for convenience. (HP) *Keywords:* invertebrate*, taxonomy*

12 **ALLRED, D.M. 1971. Ecological notes on recently described Myriapods from Nevada. Great Basin Naturalist Memoirs 31(3):161-163.**

Chilopods of six species and millipeds of four species are known from the Nevada Test Site. Those of greatest abundance and most widespread ecologically are *Scolopendra michelbacheri* and *Arinolus nevadae*, respectively. Myriapods were more abundant in the *Pinus-Juniperus*, *Grayia-Lycium*, *Lycium*, and mixed brush plant communities. Greatest numbers were found during November from 1959 to 1962. (HP) *Keywords:* perennial plants*, invertebrate*, ecology/ecosystem*, taxonomy*

13 **ALLRED, D.M. 1972. Notes on Nevada solpugids. Great Basin Naturalist Memoirs 32:120.**

Hemerotrecha branchi was taken at Cane Springs, Nevada Test Site, and *Hemerotrecha jacintoana* was collected in a *Coleogyne* plant community, extending its range to Nevada. (TPO) *Keywords:* wetlands*, vegetation*, invertebrate*, ecology/ecosystem*, taxonomy*

14 **ALLRED, D.M. 1973. Additional records of mutillid wasps from the Nevada Test Site. Great Basin Naturalist Memoirs 33:156-162.**

Ferguson (1967) listed 31 spp. of mutillids from the Nevada Test Site, USA. Three additional records are herein recorded: *Chyphotes melaniceps, C. petiolatus* and *Dasymutilla klugii*. Vegetational and ecological data are presented for each species. (JJB) *Keywords:* vegetation*, invertebrate*, ecology/ecosystem*, taxonomy*

15 **ALLRED, D.M. 1973. Effects of a nuclear detonation on arthropods at the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 18(4), 20 pp.**

Fifty-three arthropod species were studied in an area affected by an underground nuclear detonation (Project Sedan). These were represented by 10 species of ants, 17 beetles, 5 orthopterans, 4 scorpions, 6 solpugids, and 11 spiders. Relative populations were determined prior to the detonation and at three periods after the detonation: (1) one and two months after (August and September 1962), (2) 11 months after (June 1963), and (3) 13 months after (August 1963). One and two months after the detonation, the number of species was reduced from the expected by 48%, by 52% after 11 months, and by 66% after 13 months. Greatest reduction of specimens occurred with spiders, followed by ants and beetles. Fewest changes occurred in the number of scorpions. Populations of each group changed significantly in each period. Reductions from 30% to 100% occurred in all groups in all periods after the detonation except for the scorpions one and two months after, when an increase of 160% was noted. After 11 months, spiders had increased 33%. Within specific sectors, populations did not vary significantly from the expected except in a few instances. In August and September 1962, immediately after the detonation, populations of arthropods in sectors 3, 4, and 5 were much higher than expected. This represented the area from approximately 65 m to 140 m from GZ. The increase may have been due primarily to the physical transport and initial survival of those arthropods living closer to GZ than 65 m. (Author) *Keywords:* perturbations*, perennial plants*, invertebrate*, ecology/ecosystem*, radiation*

16 **ALLRED, D.M. 1973. Records of Coreidae (Hemiptera) from the Nevada Test Site. Great Basin Naturalist Memoirs 33:123.**

Arhyssus Zateratis (Say), *Arhyssus* sp., *Harmostes angustatus* Van Duzee, *H. reflexulus* (Say) and *Liorhyseus hyalinus* (F.) were identified from approximately 240 coreids collected at the Nevada Test Site, USA. (JJB) *Keywords:* invertebrate*, taxonomy*

17 **ALLRED, D.M., and D.E. BECK. 1962. Ecological distribution of mites on lizards at the Nevada atomic test site. Herpetologica 18:47-51.**

Ecological investigations at the Nevada Test Site included studies of reptiles and their ectoparasites. It was noted that an analysis of data shows that the areas of greatest infestation by two species of mites, *Odontacarus arizonensis* and *Eutrombicula belkini* were in the directions of fallout from atomic detonations. The data are presented in the following sequence for each species of mite: host, dates of collection with total number of mites collected, numbers of lizards from which taken. (HP) *Keywords:* perturbations*, invertebrate*, reptile*, ecology/ecosystem*

18 **ALLRED, D.M., and D.E. BECK. 1963. Comparative ecological studies of animals at the Nevada Test Site. In: (Schultz, V., and A.W. Klement, Jr., Eds.) *Radioecology*, Proceedings of the First National Symposium on Radioecology, pp. 327-331.**

Brigham Young University studied the comparative ecology of the native fauna of the Nevada Test Site beginning in 1959 to investigate the effects of nuclear detonations on animals. This was one of three separate projects operating in a coordinated manner. New Mexico Highlands University studied effects of nuclear testing on desert plants, and the University of California at Los Angeles studied biological availability of radionuclides to both plants and animals. The Brigham Young University group determined kinds, populations, geographical and seasonal distribution, migration, home range and other habits of native animals. Tissue changes of animals contaminated with radioactivity were compared with animals from noncontaminated areas. The greatest total number of animal species was found in areas disturbed by nuclear tests. The second greatest number of species was found in the *Larrea* community which may be typical of the Mohave. The greatest numbers of individuals of invertebrates were found in disturbed areas but this was not true of mammals. Kangaroo rats in disturbed areas ranged from three to ten times farther than those in undisturbed communities. (HP) *Keywords:* perturbations*, vegetation*, invertebrate*, vertebrate*, mammal*, ecology/ecosystem*, radiation*

19 **ALLRED, D.M., and D.E. BECK. 1963. Ecological distribution of some rodents at the Nevada atomic test site. Ecology 44:211-214.**

There were varied correlations between occurrence and relative abundance of rodents and total plant cover at the test site. Plant height plus cover may be important, for animals of 7 or 8 species studied were most common in the 2 plant communities *Coleogyne* and *Grayia-Lycium*, where the product of total cover multiplied by average height of predominant plants was greatest. The texture of the soil is an important influencing factor, especially for burrowing animals. Antelope squirrels, grasshopper mice, little pocket mice, long-tailed pocket mice and Merriam's rats were most abundant at the test site where average penetrability of the soil was more than 50 cm and there were relatively few rocks larger than approximately 3 cm in diameter. (HP) *Keywords:* vegetation*, soil property*, mammal*, ecology/ecosystem*

20 **ALLRED, D.M., and D.E. BECK. 1963. Range of movement and dispersal of some rodents at the Nevada atomic test site. Journal of Mammalogy 44:190-200.**

Range of movement and dispersal of *Ammospermophilus leucurus, Dipodomys merriami, D. microps, Onychomys torridus, Peromyscus maniculatus, Perognathus formosus and P. longimembris* were studied for over a year at the Atomic Test Site, Mercury, Nevada. Traps were operated more than 25,000 trap nights in five different plant associations. Recapture data, range of movement distances, maximum dispersal distances and range of movement patterns are given. The influence of nuclear disturbance on range of movement of small mammals was noticeable. This is not unusual, for one may expect physical disturbance of any landscape caused by such factors as overgrazing, flooding, burning or erosion to result in ranges of different size from undisturbed areas. (Authors) (HP) *Keywords:* perturbations*, vegetation*, mammal*, ecology/ecosystem*

21 **ALLRED, D.M., and D.E. BECK. 1964. Arthropod associates of plants at the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 5(2), 16 pp.**

Plant-arthropod associations related to the predominant plants in several plant communities at the Nevada Test Site were determined. Special emphasis has been directed to the identification of kinds, relative numbers, seasonal incidence, and distribution relative to plant communities as well as plant species. Plants of eleven species were studied. (HP) *Keywords:* vegetation*, invertebrate*, ecology/ecosystem*

22 **ALLRED, D.M., and D.E. BECK. 1964. Mites on reptiles at the Nevada atomic test site. Trans. Amer. Microscopical Soc. 83: 266-268.**

Additional records of mites found on reptiles at the Nevada Test Site included the host's name, the numbers examined and found infested, the number and stage of development of the mites, the date of collection and the plant community where known. The mites on snakes were found under the ventro-lateral scales. The predominant species at the Nevada Test Site was *Trombicula arenicola*. In these studies *Sauromalus obesus* seemed to be their preferred host. The predominant mite on lizards at the Nevada Test Site was *Odontacarus arizonensis*. (HP) *Keywords:* vegetation*, invertebrate*, reptile*, ecology/ecosystem* , life history*

23 **ALLRED, D.M., and D.E. BECK. 1965. A list of Scarabaeidae beetles of the Nevada Test Site. Great Basin Naturalist Memoirs 25:77-79.**

Studies dealing with selected groups of arthropods yielded a number of beetles of the family Scarabaeidae. In sequence of greatest abundance, the most common species known to occur at the test site are *Paracotalpa granicollis, Aphodius fucosus, Diplotaxis subangulata* and *Aphodius nevadensis*, respectively. Seasonally, the greatest numbers of species in the adult stage were most active in July, June, August and May, respectively, although greatest numbers of individuals were found in January, July, April, August and December. (HP) *Keywords:* invertebrate*, ecology/ecosystem*, life history*, taxonomy*

24 **ALLRED, D.M., and D.E. BECK. 1967. Spiders of the Nevada Test Site. Great Basin Naturalist Memoirs 27:11-25.**

During 1959-1965 more than 5,600 spiders were collected on the Nevada Test Site, and included 94 species of 65 genera in 22 families, not counting approximately 17 new species to be reported on later. The greatest number of spiders were collected in June-July although populations remained high between June-September. The greatest numbers of species were collected in the *Coleogyne* and mixed vegetation associations, while the largest populations were found to be in the *Coleogyne* and *Salsola* associations. Fewest species were found in the Pinyon-Juniper association, and the lowest populations were in the *Grayia-Lycium* association. (TPO) *Keywords:* vegetation*, invertebrate*, ecology/ecosystem*, taxonomy*

25 **ALLRED, D.M., and M.A. GOATES. 1964. Mites from mammals at the Nevada Test Site. Great Basin Naturalist Memoirs 24:71-73.**

Additional collections of mites on vertebrate hosts represent eleven new mite-host associations, ten new distribution records for the test site and apparently for Nevada and an unusual record of erythraeid mites of the genus *Caeculisoma* crawling on bats. These larvae are normally parasitic on arthropods. (HP) *Keywords:* invertebrate*, mammal*, ecology/ecosystem*, taxonomy*

26 **ALLRED, D.M., and M.A. GOATES. 1964. Mites from wood rats at the Nevada nuclear test site. Journal of Parasitology 50:171.**

Twenty-seven species of mites were taken from 56 wood rats, *Neotoma lepida*. The two most common species taken were *Erenisterna utahensis* and *Trombicula allredi*. Except for five species of chiggers, mites occurred on the rats in relatively small numbers. Mesostigmatid mites were found throughout the year with greatest numbers taken during spring and summer. Chiggers occurred most frequently in late summer and autumn. (HP) *Keywords:* invertebrate*, mammal*, ecology/ecosystem*

27 **ALLRED, D.M., and S. MULAIK. 1965. Two isopods of the Nevada Test Site. Great Basin Naturalist Memoirs 25:43-47.**

At the Nevada Test Site, 490 isopods of two species were collected. *Armadillo arizonicus* were most commonly associated with *Lycium pallidum* and least with *Atriplex confertifolia-Kochia americana*. *A. arizonicus* was active only in May through October. Highest populations occurred during August for adults and July through September for immatures. All but one of the 109 specimens of *Porcellio laevis* were taken at Cane Springs in a mixed plant community. Highest populations of adult males appeared August through December and females August through October. (HP) *Keywords:* wetlands*, vegetation*, invertebrate*, ecology/ecosystem*

28 **ALLRED, D.M., D.E. BECK, and C.D. JORGENSEN. 1963. Biotic communities of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 2(2), 52 pp.**

Studies by Brigham Young University were designed to develop standards of measurement to determine past nuclear effects, so far as possible, as well as to measure the effects of future tests. Study sites were established in (1) test areas where visible effects of nuclear detonations were obvious, (2) contiguous areas where no physical effects were evident, and (3) areas several miles distant from centers of nuclear detonations. Objectives were to determine kinds, population, seasonal occurrence, geographic and ecological distribution, migration, home range, and related habits of native animals in these areas. This report identified, delineated and described the major plant communities of the Nevada Test Site, and included a listing of predominant animals occurring in these communities, with a designation of their relative abundance and seasonal occurrence and listed phylogenetically all the species of animals known from the test site and communities in which they are found. (HP) *Keywords:* perturbations*, vegetation*, invertebrate*, vertebrate*, ecology/ecosystem*, taxonomy*

29 **ALLRED, D.M., D.E. BECK, and C.D. JORGENSEN. 1963. Nevada Test Site study areas and specimen depositories. Brigham Young University Science Bulletin, Biological Series 2(4), 15 pp.**

This paper supplements the publication, "Biotic Communities of the Nevada Test Site" (Allred, Beck and Jorgensen, 1963) by supplying additional information on the specific location and ecological peculiarities of the collection stations and listing the depositories of the specimens. (HP) *Keywords:* vegetation*, invertebrate*, vertebrate*, ecology/ecosystem*, taxonomy*

30 **ALLRED, D.M., D.E. BECK, and C.D. JORGENSEN. 1964. Close-in effects of an underground nuclear detonation on small mammals and selected invertebrates. USAEC Report PNE-226F, 22 pp.**

Sedan was detonated in the northern portion of Yucca Flat where the native vegetation was probably *Coleogyne ramosissima*, *Grayia spinosa* and *Lycium andersonii*. When Sedan was detonated, ground zero was surrounded almost entirely by herbaceous vegetation dominated by *Salsola kali*. Small mammal populations varied between the two vegetative zones before the test. *Perognathus parvus, Dipodomys ordii*, and *Dipodomys merriami* were more abundant in the Herbaceous zone, *Dipodomys microps* was more abundant in the Shrub zone, and *Ammospermophilus leucurus*, *Onychomys torridus*, and *Perognathus Longimembris* were equally abundant in each zone. The vegetation had not established itself sufficiently one year after detonation to allow small mammals to reinvade post-test zone 1. (HP) *Keywords:* perturbations*, invasive species*, vegetation*, annual plants*, perennial plants*, invertebrate*, mammal*, ecology/ecosystem*

31 **ALLRED, D.M., D.E. BECK, and C.D. JORGENSEN. 1965. A summary of the ecological effects of nuclear testing on native animals at the Nevada Test Site. In: Proceedings of the Utah Academy of Sciences, Arts and Letters 42:252-260.**

Abnormalities which may be definitely attributed to the effects of radiation on the somatoplasm or the germ plasm of the native animals were not found during the studies. Some differences which were found, such as changes in fur color, have also been observed elsewhere in areas not associated with nuclear testing and fallout. On the basis of ecological distribution in nuclear disturbed areas, however, differences were found in the species composition in areas where the biota were disturbed but not completely destroyed. For the most part, these studies dealt with the fauna of the basins, playas and valleys of the test site. (HP) *Keywords:* perturbations*, vertebrate*, ecology/ecosystem*, physiology*, radiation*

32 **ALLRED, D.M., D.E. JOHNSON, and D.E. BECK. 1965. A list of some beeflies of the Nevada Test Site. Great Basin Naturalist Memoirs 25:5-11.**

Several thousand beeflies were identified representing 111 species of 24 genera. The species, number of individuals collected, months of occurrence, and ecological distribution are given. Species which were taken in the most abundant numbers at the test site are *Lordotus albidus*, *Lordotus nigriventris*, and *Poecilanthrax apache*. The beeflies most widely distributed ecologically are *Paracosmus morrisoni*, *Poecilanthrax apache* and *Villa aenea*. The greatest number of species and individuals were found in mixed and *Larrea-Franseria* communities. Seasonally the greatest number of species and individuals occurred in May, June, April, and September, respectively. (HP) *Keywords:* vegetation*, invertebrate*, ecology/ecosystem*, taxonomy*

33 **AMY, P.S., C. DURHAM, D. HALL, and D.L. HALDEMAN. 1993. Starvation-survival of deep subsurface isolates. Current Microbiology 26:345-352.**

Six deep, subsurface endolithic isolates were subjected to starvation conditions for up to 100 days in artificial pore water, formulated to mimic in situ geochemical conditions in the nearly saturated rock. Most isolates demonstrated the typical starvation-survival curve for chemoheterotrophic bacteria, and all became miniaturized during starvation. Starvation indices were developed to compare changes in viable cell counts between isolates. Two isolates retained higher viability after 100 days of starvation-survival. High survival correlated with sustained respiration, measured by iodonitrotetrazolium-formazan production, during starvation. In all but one case, isolates plated on two nutritionally dilute media, metal-containing and antibiotic-containing media, showed similar viable counts. (Authors) *Keywords:* geology*, microbiota*, nutrition/diet*

34 **AMY, P.S., D. L. HALDEMAN, D. RINGELBERG, D.H. HALL, and C. RUSSELL. 1992. Comparison of identification systems for classification of bacteria isolated from water and endolithic habitats within the deep subsurface. Applied and Environmental Microbiology 58(10):3367-3373.**

One water and three rock samples were taken from a mined tunnel system, U12n, in Rainier Mesa at the Nevada Test Site. Endolithic microorganisms were cultured from ashfall tuff, which was crushed and made into slurries with a formulation of artificial pore water, on R2A agar plates. Microbial counts ranged from 10^2 to 10^4 viable cells per g (dry weight) of rock sampled. The cultured water sample yielded 10^2 viable cells per ml. Many of the isolates were very small (<1 µm) when viewed in the rock matrix and remained small even when cultured. Most were gram-negative rods. Individual isolates were profiled by API-NFT strip number, antibiotic and metal resistance patterns, and colony and cellular morphologies. Three identification systems, API-NFT strips, BIOLOG, and MIDI, were compared. Each system identified only a small percentage of the total isolates, and in only seven cases were the isolates identified the same way by more than one system. The same genus was identified in three of these cases, but different species were indicated. The genus *Pseudomonas* was the most commonly identified. The isolate profiles and the three identification systems demonstrated that water isolates were considerably different from endolithic isolates. (Authors) *Keywords:* geology*, microbiota*, nutrition/diet*, methods*

35 **ANDERSON, A.O., and D.M. ALLRED. 1964. Kangaroo rat burrows at the Nevada Test Site. Great Basin Naturalist Memoirs 24:93-101.**

The nature of burrows made by the kangaroo rat, *Dipodomys microps occidentalis*, was studied. Such information is important in evaluating the radiation dosage a rat may receive while in its burrow, and the effects of soil compaction from over-pressure of a nuclear detonation. Data and illustrations are presented for the pattern of burrows in five habitats. Included in the data are burrow depths, number of openings and side burrows, site of food caches and type of food stored within. (FMM) *Keywords:* mammal*, ecology/ecosystem*

36 **ANDERSON, D.C. 1998. Distribution of Clokey's Eggvetch (*Astragalus oophorus* var. *clokeyanus*) on the Nevada Test Site. DOE/NV/11718–262. Bechtel Nevada, Las Vegas, NV.**

The Environment, Safety and Health Division of the U.S. Department of Energy, Nevada Operations Office (DOE/NV) implements the Ecological Monitoring and Compliance Program on the Nevada Test Site (NTS). This program ensures compliance with applicable environmental laws and regulations, delineates and describes NTS ecosystems, and provides ecological information for predicting and evaluating potential impacts of proposed projects on those ecosystems. Over the last several decades, the U.S. Department of Energy, Nevada Operations Office has taken an active role in providing information on the status of plant species proposed for protection under the Endangered Species Act (ESA). One such species is Clokey's eggvetch (*Astragalus oophorus var. clokeyanus*), which is a candidate species under the listing guidelines of the ESA. Surveys for this species were conducted on the NTS in 1996, 1997, and 1998. Field surveys focused on potential habitat for this species in the southern Belted Range and expanded to other areas with similar habitat. Over 30 survey days were completed; five survey days in 1996, 25 survey days in 1997, and three survey days in 1998. Clokey's eggvetch was located at several sites in the southern Belted Range. It was found through much of the northern section of Kawich Canyon, one site at the head of Gritty Gulch, and a rather extensive location in Lambs Canyon. It was also located further south at Captain Jack Springs in the Eleana Range, in much of Falcon Canyon and around Echo Peak on Pahute

Mesa, and was also found in the Timber and Shoshone Mountains. Overall, the locations of Clokey's eggvetch on the NTS appears to form a distinct bridge between populations of the species located further north in the Belted and Kawich Ranges and the population located in the Spring Mountains. Clokey's eggvetch was commonly found along washes and small draws, and typically in sandy loam soils with a covering of light tuffaceous rock. It occurs primarily above 1,830 meters (6,000 feet) in association with single-leaf pinyon (*Pinus monophylla*), Utah juniper (*Juniperus osteosperma*), and big sagebrush (*Artemisia tridentata ssp. tridentata*). Overall, the populations of Clokey's eggvetch on the NTS appear to be vigorous and do not appear threatened. It is estimated that there are approximately 2,300 plants on the NTS. It should be considered as a species of concern because of its localized distribution, but it does not appear to warrant protection under the ESA. (Author) *Keywords:* soil property*, sensitive plants*, vegetation*, ecology/ecosystem*, life history*

37 **ANGERER, J.P., W.K. OSTLER, W.D. GABBERT, and B.W. SCHULTZ. 1994. Secondary Succession on Disturbed Sites at Yucca Mountain, Nevada. EG&G Energy Measurements Report. EGG 11265-1118 UC-702. Las Vegas, NV, pp. 73**.

This report presents the results of a study of secondary plant succession on disturbed sites created during initial site investigations in the late 1970s and 1980s at Yucca Mountain, NV. Specific study objectives were to determine the rate and success of secondary plant succession, identify plant species found in disturbances that may be suitable for site-specific reclamation, and to identify environmental variables that influence succession on disturbed sites. During 1991 and 1992, fifty seven disturbed sites were located. Vegetation parameters, disturbance characteristics and environmental variables were measured at each site. Disturbed site vegetation parameters were compared to that of undisturbed sites to determine the status of disturbed site plant succession. Vegetation on disturbed sites, after an average of ten years, was different from undisturbed areas. *Ambrosia dumosa, Chrysothamnus teretifolius, Hymenoclea salsola, Gutierrezia sarothrae, Atriplex confertifolia, Atriplex canescens,* and *Stephanomeria pauciflora* were the most dominant species across all disturbed sites. With the exception of *A. dumosa,* these species were generally minor components of the undisturbed vegetation. Elevation, soil compaction, soil potassium, and amounts of sand and gravel in the soil were found to be significant environmental variables influencing the species composition and abundance of perennial plants on disturbed sites. The recovery rate for disturbed site secondary succession was estimated. Using a linear function (which would represent optimal conditions), the recovery rate for perennial plant cover, regardless of which species comprised the cover, was estimated to be 20 years. However, when a logarithmic function (which would represent probable conditions) was used, the recovery rate was estimated to be 845 years. Recommendations for future studies and site-specific reclamation of disturbances are presented. (Authors) *Keywords:* YMSCO*, soil property*, perturbations*, perennial plants*, ecology/ecosystem*

38 **ANGERER, J.P., V.K. WINKEL, W.K. OSTLER, and P.F. HALL. 1995. Spatial and Temporal Variability of Microbes in Selected Soils at the Nevada Test Site. In: Proceedings of the Wildland Shrub and Arid Land Restoration Symposium Las Vegas, NV, October 19-21, 1993. Roundy, B.A., E.D. McArthur, J.S. Haley, and D.K. Mann (Compilers). Gen. Tech. Rep. INT-GTR-315. U.S. Department of Agriculture, Forest Service; Intermountain Research Station, Ogden, UT, pp. 157-164.**

Large land areas encompassing almost 700 hectares on the U.S. Department of Energy Nevada Test Site, Nellis Air Force Range and the Tonopah Test Range are contaminated with plutonium. Plutonium decontamination of these sites may involve removal of plants and almost 370,000 cubic meters of soil from the sites. The soil may be subjected to a series of plutonium removal processes. After decontamination, the soils may be returned to the site and revegetated. Because a paucity of information exists on the microbial components of the Mojave and Great Basin Deserts, especially how the components vary spatially and temporally, this study was initiated to determine baseline microbial activity and biomass in soils prior to decontamination. Information from this study will aid in determining the effects of plutonium decontamination on soil microorganisms, and what measures, if any, will be required to restore microbial populations upon subsequent revegetation of these sites. Soils were collected to a depth of 10 cm along each of five randomly located 30-m transects at each of four sites. In order to ascertain spatial differences, soils were collected from beneath major shrubs and from associated interspaces. Soils were collected at 3 to 4 month intervals to determine temporal (seasonal) differences in microbial parameters. Analysis showed that soils from beneath shrubs generally had greater active fungi and bacteria, and greater non-amended respiration than soils from interspaces. Temporal variability in the microbial components were found, with total and active fungi, and non-amended respiration being highly correlated to soil moisture at the time of sampling. (Authors) *Keywords:* microbiota*, ecology/ecosystem*, revegetation*

39 **ANONYMOUS. 1973. Environmental Statement: Underground nuclear testing program, Nevada Test Site, April 1973.**

USAEC Report WASH-1526, 130 pp.

The environmental impact of continuing underground nuclear tests and preparations for tests of one megaton or less at the Nevada Test Site (NTS) is reported. Information is included on the selection, geology, hydrology, environmental setting, and history of the NTS; the seismic and radiological impact of underground nuclear explosion testing; the commitment of resources; alternatives to testing; and review procedures. Two appendices of bioenvironmental studies of the NTS and comments by the AEC and other agencies on the environmental impact report are included. It is concluded that the environmental impact due to continued testing at the NTS will be small. No observable or significant environmental effects are expected from radioactivity release. The explosions will create several nuclear subsidence craters, minor rock falls on cliffs in the area, and underground pockets of high radioactivity, but only minor property damage from ground motions and no triggering of earthquakes. The benefits to nuclear weapons technology and Plowshare technology from continued underground testing are considered to exceed the environmental costs. (LCL) *Keywords:* geology*, hydrology*, perturbations*, radionuclide inventory*, vegetation*, vertebrate*, ecology/ecosystem*, radiation*

40 **ANONYMOUS. 1973. Selected census information around the Nevada Test Site. NERC-LV-539-8, 11 pp.**

The National Environmental Research Center-Las Vegas (NERC-LV), Environmental Protection Agency, conducts a comprehensive offsite radiological safety program in support of nuclear testing at the Nevada Test Site (NTS). To facilitate the planning and management of required surveillance and monitoring operations, and to assess potential and actual population exposures resulting from radioactive releases into the areas beyond the boundaries of the NTS, the NERC-LV collects and maintains census information in the area around the NTS. This report summarizes this census information which includes the number and distribution of resident adults and children, family milk cows, and Grade A dairy cows located by azimuth and distance within a radius of 450 miles of Control Point 1 at approximately the center of the NTS, 36Ķ 15' N, 116Ķ 04' W. (TPO) *Keywords:* EPA*, radionuclide inventory*, mammal*, radiation*

41 **ANONYMOUS. 1975. Underground nuclear testing program, Nevada Test Site: Final Supplement to Environmental Statement WASH-1526 (April 1973). WASH-1526 Supplement, 76 pp.**

This document supplements Environmental Impact Statement WASH-1526 which assessed the environmental impact of underground nuclear tests and preparations for tests of one megaton or less at the Nevada Test Site. Significant new information on waste management and the Nevada Applied Ecology Group is included. (TPO) *Keywords*: geology*, hydrology*, perturbations*, radionuclide inventory*, vegetation*, vertebrate*, ecology/ecosystem*, radiation*, NAEG*

42 **ANSPAUGH, L.R., P.L. PHELPS, N.C. KENNEDY, and H.G. BOOTH. 1973. Winddriven redistribution of surface-deposited radioactivity. In: Proceedings of the Symposium on Environmental Behaviour of Radionuclides Released in the Nuclear Industry, Aix-en-Provence, France, 1973 (CONF-730503), pp. 167-184.**

The deposition of radionuclides on a terrestrial surface can result in the delivery of dose to man through external radiation exposure, food chain contamination or inhalation of suspended particles. ^{239}PU is one of the few radionuclides generally regarded as constituting an inhalation hazard through wind-driven resuspension. No adequate models of resuspension exist. Two major problem areas have been identified: the rate at which initially deposited debris weathers into a less erodible state as a function of time, and a source term factor in material removed per unit time per unit area, applicable to a source of any configuration. In experiments conducted at the U.S. Atomic Energy Commission's Nevada Test Site, concentrations in air of particles moving in suspension were studied over a period of six weeks following the nuclear cratering event Project Schooner and over a 10-month period following accidental venting of an underground nuclear explosion. Suspended air activity was observed to decrease in time with half-times of from 35 to 80 days; this factor appears to be much more important than variations in meteorological parameters over these relatively short time periods. Movement of small particles in suspension accounts for only a minor fraction of the total mass movement. As much as 50% of the initially deposited debris was moved by saltation within a 24-hour period. Such movement can result in extensive micro-inhomogeneities with accumulation of debris under bushes or other places affording shelter from erosive forces. More detailed study of the resuspension process in an aged ^{239}PU field is now in progress. Preliminary data are given on the particle size distribution of the total mass and the ^{239}PU moving in suspension. (Authors) *Keywords*: radionuclide inventory*

43 **ANSPAUGH, L.R., P.L. PHELPS, N.C. KENNEDY, H.G. BOOTH, R.W. GOLUBA, J.R. REICHMAN, and J.S. KOVAL. 1974. Resuspension of plutonium: a progress report. USAEC Report UCRL-75484, Preprint, 111 pp.**

Progress is reported for a research program on the resuspension in the atmosphere of plutonium fallout deposited on the earth's surface. The long-range goal of the resuspension studies is to produce a set of equations which can be used to predict the time-dependent average concentration of resuspended material downwind from a source of any geometrical configuration and soil surface characteristics. The experiments are conducted at the Nevada Test Site where plutonium-high explosive tests were performed from 1954 to early 1956. The investigations have included: monitoring of soil samples for Pu; development of ultra-high volume air samplers, in-situ particle spectrometers, particle counters, and a micrometeorology field laboratory; determination of Pu redistribution due to the rolling of soil particles pushed by winds (creep), the bouncing of wind-pushed particles (saltation), and transport by dust devils; and measurements of meteorological parameters. Results from these experiments will be used to establish a data bank on radioisotope distribution and meteorological conditions at NTS and to provide information of the relation between the source and the dose to man from existing radioactivity. (LCL) *Keywords:* radionuclide inventory*, mammal*, radiation*

44 **AU, F.H.F. 1974. The Role of Soil Microorganisms in the Movement of Plutonium. In: *The Dynamics of Plutonium in Desert Environments*. Dunaway, P.B., and M.G. White (Eds.). NVO-142, U.S. Atomic Energy Commission, Nevada Operations Office, Las Vegas, NV, pp. 135-141.**

Microbial studies which are completed or in progress were designed to determine the ability of microorganisms to absorb plutonium, to quantify the uptake, and to determine the microbial population of soils of the Nevada Test Site (NTS). Results of the microbial inventory of Area 13 (NTS) showed that about 2% of the *Aspergillus* was near the surface of the hummock and increased with distance away from the plants. *Penicillium*, on the other hand, showed an inverse pattern in that its relative abundance decreased away from the plants. A method was developed for *in vitro* studies in which aerial fungal spores were collected to determine soluble plutonium uptake from agar medium. The concentration of plutonium in mature spores was approximately one-fourth of that in the growth medium. (Author) *Keywords:* NAEG*, microbiota*, physiology*, radiation*, methods*

45 **AU, F., and W.F. BECKERT. 1975. Influence of Selected Variables on Transport of Plutonium to Spores of *Aspergillus Niger*. In: *The Radioecology of Plutonium and Other Transuranics in Desert Environments.* White, M.G., and P.B. Dunaway (Eds.). NVO-153, U.S. Energy Research & Development Administration, Nevada Operations Office, Las Vegas, NV, pp. 187-196.**

Studies were carried out on the influences of different chemical forms and concentrations of plutonium at two hydrogen ion concentrations of the culture medium on uptake and transport of plutonium to the spores of *Aspergillus niger*. Results indicated that plutonium, when added to the culture medium as dioxide microspheres, nitrate, or citrate complex, was transported to the spores, and that an almost linear relationship existed between transport and concentration. Raising the pH of the culture medium from 2.5 to 5.5 generally increased transport of plutonium to spores for all three chemical forms. At plutonium concentrations of 224 pCi/g in the culture media, and for both pH 2.5 and 5.5, transport of plutonium to spores was approximately three times as high from the nitrate or citrate form as from the dioxide microspheres. (Authors) *Keywords:* NAEG*, microbiota*, radiation*, physiology*

46 **AU, F.H.F., and W.F. BECKERT. 1977. Influence of Microbial Activities on Availability and Biotransport of Plutonium. In: *Environmental Plutonium on the Nevada Test Site and Environs.* White, M.G., P.B. Dunaway, and W.A. Howard (Eds.). NVO-171, Nevada Applied Ecology Group, U.S. Energy Research & Development Administration, Las Vegas, NV, pp. 219-226.**

In this report, the data and conclusions from previous studies are summarized and discussed in context. Special attention is directed toward the effects of native vegetation and agricultural practices on soil microbial populations and the probable effects of changes in these microbial populations on the bioavailability and transport of plutonium to plants. In addition, the biological movement of transuranics in soil systems is addressed. A special technique developed for these studies to collect small particles is briefly outlined. The use of this technique, which eliminated cross-contamination problems, made possible uptake studies with various plutonium compounds using the soil fungus *Aspergillus niger*. The same technique is applicable to various phases of ongoing studies. Experiments currently in progress are designed to elucidate the roles of various common soil microorganisms on the movement of transuranics in soil and on the bioavailability of transuranics to plants and animals. The results of these studies are expected to bring us one step closer toward a broader understanding of the importance of soil microbial interaction with transuranics in the environment. (Authors) *Keywords:* NAEG*, microbiota*, vegetation*, physiology*, radiation*, methods*

47 **AU, F.H.F., and W.F. BECKERT. 1978. Microbial Contributions to Plutonium Bioavailability and Transport in the Environment. In: *Selected Environmental Plutonium Research Reports of the NAEG.* White, M.G., and P.B. Dunaway (Eds.). NVO-192 Volume 1, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 95-108.**

New experimental results show that plutonium which is incorporated in fungal tissue is available for uptake and translocation to the spores of new growth of *Aspergillus niger*. The transport factors derived from the present and past experiments are compared and discussed as to their meaning for the bioavailability of environmental plutonium to other organisms with time. This report includes a synopsis of our investigations which were undertaken to show the effect of soil microorganisms on the transport and bioavailability of plutonium in a desert environment. The uptake of plutonium by a soil fungus, the effect of microbial biomass on plutonium transport, and the correlation between soil microbial populations and plutonium uptake by plants grown on contaminated soil are discussed. (Authors) *Keywords:* NAEG*, microbiota*, vegetation*, physiology*, radiation*

48 **AU, F.H.F., and V.D. LEAVITT. 1985. The Soil Microbiota of Area 13 of the Nevada Test Site. In: *The Radioecology of Transuranics and other Radionuclides in Desert Ecosystems.* Howard, W.A., P.B. Dunaway, and R.G. Fuller (Eds.). NVO-224, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 201-242.**

The influence of two desert plants, *Atriplex canescens* and *Eurotia lanata*, on kind and abundance of soil microbiota was determined on soil samples collected from Area 13 of the Nevada Test Site. This study was part of a larger research program to elucidate the role of soil microorganisms on the biological availability and the mobility of soil-deposited plutonium. The fungi identified in the soil samples included *Aspergillus, Penicillium, Rhizopus, Stachybotrys, Stysanus, Circinella, Cheaetomium,* and *Fusarium*. The numbers of bacteria and fungi were generally highest at the 2.5- to 5.0-cm soil depth at both the mound and the interspace sampling sites. The highest numbers of fungi were found around the mound. The relative abundance of *Aspergillus* increased with increasing distance from the plants, whereas that of *Penicillium* decreased. *Dematiaceae* and *Chaetomium*, both cellulose decomposers, were highest in the 0- to 2.5-cm soil segment. The abundance and distribution of soil microorganisms capable of incorporating plutonium (and probably other radionuclides as well) around the plants investigated indicate that this may be a factor in the bioavailability and movement of plutonium in the edaphic system. (Authors) *Keywords:* NAEG*, microbiota*, perennial plants*, ecology/ecosystem*, radiation*, taxonomy*

49 **AU, F.H.F., V.D. LEAVITT, and W.F. BECKERT. 1976. Possible Influence of Desert Soil Microbial Changes. In: *Studies of Environmental Plutonium and Other Transuranics in Desert Ecosystems.* White, M.G., and P.B. Dunaway (Eds.). NVO-159, U.S. Energy Research & Development Administration, Nevada Operations Office, Las Vegas, NV, pp. 67-79.**

The soil microbial population was determined for soil depth segments from 0-3 cm, 3-6 cm, and 6-9 cm in a previously uncultivated high-desert area. Plots in this area were covered by miniature greenhouses and planted with vegetables. After harvesting the vegetable crops, another assessment was made of the microbial population. The fungal population nearly doubled during the growing season, and the bacterial population increased by a factor of approximately 12. The fungal and bacterial live weights per hectare of the investigated desert soil were calculated and compared with those of agricultural soils. Possible consequences of the increase in microbial biomass are discussed for plutonium availability to plants, and for plutonium migration in soil. (Authors) *Keywords*: NAEG*, microbiota*, annual plants*, ecology/ecosystem*, radiation*

50 **AUSMUS, B.S., and G.J. DODSON. 1978. Effects of Transuranics on Desert Ecosystems Processes: An Exploratory Study. In: *Selected Environmental Plutonium Research Reports of the NAEG.* White, M.G., and P.B. Dunaway (Eds.). NVO-192 Volume 1, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 143-156.**

An exploratory study investigating the effects of stress on desert ecosystem processes was conducted. Uncontaminated soil profiles were excised intact from seven sites in Area 18 and established as microcosms in an environmental chamber at field ambient conditions. Based on studies in mesic ecosystems, $C0_2$ efflux was chosen as a parameter to monitor through time. Microcosms were monitored 5 months to establish parameter behavior and any differences among sites. To determine the effect of stress on $C0_2$ efflux, seven treatment doses of $CdCl_2$ were applied to soils randomly across sites. Data following treatment show $C0_2$ efflux increases due to doses of 3.89, 7.78, and 77.8 mg/cm^2. Extractable Ca and extractable $N0_3$-N were significantly reduced at one or more treatment doses at harvest. Extractable $P0^4$-P was not affected. This exploratory study confirms the utility of microcosm techniques for measuring the effects of stress upon a desert ecosystem. Further refinement of these techniques will allow: (1) the effects of transuranics on ecosystem processes to be quantified, and (2) feasibility of decontamination or stabilization alternatives to be tested in the laboratory prior to field trials. (Authors) *Keywords:* NAEG*, perturbations*, microbiota*, ecology/ecosystem*, radiation*, methods*

51 **BAKER, D.E., K.K.S. PILLAY, A.W. ROSE, and E.J. CIOLKOSZ. 1978. Development on an Approach for Monitoring the Plant Availability of Transuranics in Nevada Test Site Soils. In: *Selected Environmental Plutonium Research Reports of the NAEG*. White, M.G., and P.B. Dunaway (Eds.). NVO-192 Volume 1, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 157-176.**

Existing experimental results obtained for the accumulation of plutonium and other transuranics by vegetation from Nevada Test Site (NTS) soils are being studied to develop an approach which would be useful for predicting the availability of plutonium to plants. Site variability with respect to soil-plant relationships affects the plant production potentials for soil in any environment. Ultimately each site must be considered in relation to depth and distribution of roots, the effect of root exudates on soil particles and associated ionic species. Air-water relations, Eh, pH, and chelation effects at the soil-plant root interface are site specific characteristics which must be measured to predict the plant availability of any ion species. Existing principles and approaches for monitoring the plant availability of chemical elements in soils are only partially applicable to plutonium and other transuranic ion species in NTS soils because of the very small amounts present, the nonuniform distribution, the nonuniform chemical form, and the effects of radioactivity on chemical and physical state. These factors complicate the extension of experimental observations from analogous results for stable nuclides. As an initial step toward understanding the chemistry of plutonium in natural environment, several Eh-pH diagrams have been calculated. At equilibrium, Pu^{3+} and PUO_2CO_3OH are the important dissolved forms of Pu. Metastability of oxidation states and radiolytic effects may cause deviations from the equilibrium behavior. It is recommended that the effects of factors affecting the plant uptake of plutonium be measured for NTS soil samples in the development of an approach to soil monitoring which utilizes a "black box" model which integrates the parameters important to ionic diffusion from soil to plant roots. (Authors) *Keywords:* NAEG*, microbiota*, vegetation*, ecology/ecosystem*, radiation*, methods*

52 **BAMBERG, S.A., and A.T. VOLLMER. 1975. Unpublished report. Effects of Chronic Gamma Irradiation on Shrubs in the Northern Mojave Desert Ecosystem. UCLA, Laboratory of Nuclear Medicine and Radiation Biology, Los Angeles, CA.**

A natural desert shrub ecosystem has been chronically irradiated since January, 1964. A nine ha plot was irradiated by a differentially shielded 33,600 Ci ^{137}Cs source atop a 15 m tower. Dose rate ranges from 8 R/day to 1 R/day. Effects of irradiation on leaf and stem morphology and productivity of perennial shrub species, investigated in 1972 and 1973, are discussed. The most radiosensitive shrubs were *Ephedra nevadensis*, *Krameria parvifolia* and *Larrea divaricata*. The radiation responses of fruit production and stem spiraling showed significant response to the dosage gradient in these species. Stepwise discriminant analysis suggests that examination of radiation effects of *Krameria* and *Ephedra* can be used to assess the irradiation insult on the plant populations. Radiation induced mortality has only been observed in *Krameria*. After ten years of irradiation no significant changes in community composition or structure could be detected at this time. Compared to other ecosystems the desert shrub vegetation is more resistant to radiation. (Authors) *Keywords*: perennial plants*, radiation*, ecology/ecosystem*

53 **BAMBERG, S. A., and A. WALLACE. 1972. Gaseous exchange in Mohave Desert shrubs. US/IBP Desert Biome Res. Memo. 72-21. Utah State University, Logan, 8 pp.**

Rates of gaseous exchange are being measured in Mohave Desert shrubs with the objective of obtaining seasonal values for important plant species. CO_2 exchange and transpiration are measured using a compensating null-point Siemens' plant chamber. Net photosynthesis, transpiration and water utilization are calculated and given in weight of gas exchanged per unit dry weight of photosynthetic organ per unit time. Results indicate a high capacity for CO_2 uptake and a decreasing utilization of water as the season becomes hotter and drier. (Authors) *Keywords:* IBP*, perennial plants*, physiology*

54 **BAMBERG, S.A., G.E. KLEINKOPF, A. WALLACE, and A. VOLLMER. 1975. Comparative photosynthetic production of Mojave Desert shrubs. Ecology 56:732-736.**

Transpirational and net photosynthetic rates of several species of desert shrubs were measured as a function of season and environmental variables at the Nevada Test Site in the northern Mojave Desert. Drought-deciduous species, *Ambrosia dumosa* (Grey) Payne, *Lycium andersonii* Grey, and *Lycium pallidum* Miers, had higher maximum rates and greater water loss than the evergreen, *Larrea tridentata* Munz, and summer green, *Krameria parvifolfa* Benth., species. Moisture status was the most critical factor determining gas exchange rates and affected temperature optima and acclimation as the season progressed. Because of a dry spring season; the drought-deciduous species became dormant in late May-early June; the other two species exhibited by mid-June a small positive CO_2 uptake during the morning period. Desert plant species, with few exceptions, are extremely labile and exhibit large variability and different adaptive strategies. (Authors) *Keywords:* perennial plants*, physiology*

55 **BAMBERG, S.A., A.T. VOLLMER, G.E. KLEINHOPF, and T.L. ACKERMAN. 1976. A Comparison of Seasonal Primary Production of Mojave Desert Shrubs During Wet and Dry Years. American Midland Naturalist 95:398-405.**

Estimates of net primary productivity were made for five major shrub species in the northern Mojave Desert during 2 years of contrasting moisture regimes using harvest and gas exchange techniques. Production increased by 224% (harvest) to 260% (gas exchange) in 1973 over 1972. Production gains varies among species depending on whether the species was favored by the cool, moist spring or 1973. *Lycium andersonii* and *L. pallidum*, which have high photosynthetic rates and start growth in the early spring, showed the greatest increases. *Larrea tridentata* and *Krameria parvifolia*, species adapted to growing under warmer, drier conditions, exhibited the smallest changes in production. *Ambrosia dumosa*, which has high photosynthetic rates but responds more favorably to warmer spring temperatures than the *Lycium* species, had moderate production gains. Reasons for the different estimates obtained by these two methods are discussed. (Authors) *Keywords:* climate*, perennial plants*, physiology*, ecology/ecosystem*

56 **BAMBERG, S.A., A. WALLACE, G.E. KLEINKOPF, A. VOLLMER, and AUSMUS. 1973. Plant productivity and nutrient interrelationships of perennials in the Mohave Desert. US/IBP Desert Biome Res. Memo. 73-10. Utah State University, Logan, 24 pp.**

Gas exchange, assimilate partitioning and fate in several species of desert shrubs were measured as a function of season and environmental variables at the Nevada Test Site in the northern Mohave Desert. Gas exchange rates were determined using a Siemens null-point gas exchange apparatus (Part I) and assimilate partitioning by incorporation of $^{14}CO_2$ and subsequent whole shrub excavation (see Parts II, III, IV). Tests were done on plants in Rock Valley under natural field conditions and at Mercury under natural and manipulated conditions. Species specific differences in gas exchange rates in relation to temperature and moisture regimes were measured. Drought-deciduous species, *Ambrosia dumosa* (Gray) Payne, *Lycium andersonii* Gray and *Lycium pallidum* Miers had higher maximum rates and greater water loss than the evergreen, *Larrea divaricata* (Ses. & Moc. ex DC.) Cov., and summer green, *Krameria parvifolia* Benth., species. Moisture status was the most critical factor determining gas exchange rates and affected temperature optimums and acclimation as the season progressed. Due to a dry spring season, the drought-deciduous species became dormant in late May-early June; the other two species by mid-June exhibited a small positive CO_2 uptake during the morning period. With adequate moisture, *A. dumosa, K. parvifolia,* and *L. divaricata* continued active photosynthesis throughout the summer. *A. dumosa* and *L. divaricata* plants not watered after June 1 did not show any large differences by mid-August in photosynthesis or transpiration compared with watered plants, although there was a greater increase in tissue water potential. In terms of modeling either photosynthesis or productivity, our data for the past two years indicate a system which is highly responsive to moisture, time of year, and temperature regimes. Desert plant species, with few exceptions, are extremely labile and exhibit large variability and different adaptive strategies. (Authors) *Keywords:* IBP*, climate*, perennial plants*, physiology*

57 **BAMBERG, S.A., A. WALLACE, G.E. KLEINKOPF, A. VOLLMER, and AUSMUS. 1974. Plant productivity and nutrient interrelationships of perennials in the Mohave Desert. US/IBP Desert Biome Res. Memo. 74-8. Utah State University, Logan, UT, 16 pp.**

Studies for the past three years on plant productivity of five desert plant species have been conducted in an experimental garden at Mercury at the Nevada Test Site in the northern Mohave Desert. The plant species are *Ambrosia dumosa, Krameria parvifolia, Larrea divaricata, Lycium andersonii,* and *Lycium pallidum.* Photosynthesis, respiration and transpiration are being studied in relation to seasonal temperature, humidity and soil moisture conditions. Translocation, utilization and storage of assimilates have been studied for periods of two weeks to a year on naturally-growing shrubs. Root growth, biomass and associated ATP activity have been studied as a means of estimating below-ground activity and its relationship to below-ground productivity and biomass. There has been a large difference in the response of these desert shrubs in rates and duration of photosynthesis and total carbon uptake over the last two years. Total carbon uptake for the five shrubs increased from 142 kg/ha in 1972 to 508 kg/ha in 1973, a 257% increase in gross productivity. This increase is the result of a more favorable moisture regime in which, effective seasonal moisture was 90.6 mm in 1972 compared to 246.7 mm for 1973, an increase of 172%. Translocation of assimilates in 1972 showed only a small, but variable, proportion stored in roots. Small stems seem to be the major storage site for most assimilated carbon. This is the site where the greatest use of assimilate for new leaf and stem production occurs. Root biomass increased approximately three-fold in 1973 in response to a tremendous growing season. Preliminary results of ATP concentrations did not show a corresponding increase in biological activity, but this may have been due to a seasonality effect of increasing stress in the period of March to August, 1973, and activity may peak at different seasons. Preliminary estimates are given for total carbon input in the desert ecosystem at Rock Valley, but a total carbon budget must await the derivation of better estimates of losses to respiration, herbivory and amount of below-ground activity. (Authors) *Keywords:* IBP*, climate*, perennial plants*, physiology*, ecology/ecosystem*

58 BAMBERG, S.A., A. WALLACE, E.M. ROMNEY, and R.B. HUNTER. 1980. Further Attributes of the Perennial Vegetation in the Rock Valley Area of the Northern Mojave Desert. Great Basin Naturalist Memoirs (4):39-41.

Above-ground and below-ground biomass, percent dead shrubs by species and percent of dead stems of living species were determined for a site in the northern Mojave Desert. (Authors) *Keywords:* IBP*, perennial plants*, ecology/ecosystem*

59 BANTA, M.R. 2000. Natural Selection on Physiological Traits Associated with Water and Energy Conservation in a Desert-dwelling Rodent, Merriam's Kangaroo Rat (*Dipodomys merriami*). Ph.D. Dissertation, University of Nevada, Reno, NV.

Animals that live in desert environments need to conserve both energy and water if they are to survive. This is particularly true of mammals, such as Merriam's kangaroo rats (*Dipodomys merriami*), because both energy and water use are increased in endotherms. It is unclear whether, for kangaroo rats, the conservation of one of these limited resources (energy or water) is more important than the other, and one objective of this study was to determine whether kangaroo rats would attempt to conserve water or energy when one or both resources was limiting. In an experiment designed to allow kangaroo rats to choose environmental temperatures that would facilitate either water or energy conservation, but not both, kangaroo rats consistently chose energy conserving temperatures. This suggests that energy conservation may be more important to this species. Kangaroo rats possess a suite of physiological traits that allows them to conserve both water and energy, and these traits are presumed to be adaptations. If so, then these traits, or the hormones that regulate them, should be subject to natural selection. The hormone thyroxine regulates physiological processes important for both energy and water use in kangaroo rats. I implanted kangaroo rats with time-release pellets that contained 5.0 mg thyroxine and pellets that did not contain thyroxine (placebo). These thyroxine-implanted animals had significantly elevated thyroxine levels in their blood, elevated basal metabolic rates, but no detectable increase in water loss. In a field study, thyroxine-implanted kangaroo rats did not have lower survival rates than placebo-implanted animals, suggesting that natural selection was not acting on thyroxine levels during this study. The field study was conducted during a very wet and mild summer following an El Niño event, and it is possible that selection only acts on thyroxine levels during periods of water or energy stress, such as during a drought. I conclude that the need to conserve energy in desert environments may have led to the physiological traits that kangaroo rats currently possess. Thyroxine is important in regulating one source of energy use, basal metabolic rate, and thyroxine may be a target of selection when animals are subject to periods of energy stress. (Author) *Keywords:* vertebrate*, mammal*, physiology*

60 BARNUM, A.H. 1964. Orthoptera of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 4(3), 134 pp.

Orthoptera at the Nevada Test Site were studied in depth to classify species and provide taxonomic keys for differentiation, evaluate populations, and determine seasonal and geographic distribution in areas disturbed by atomic explosions as compared to undisturbed areas. Field observations were made from nine regular collection sites and four less frequently visited areas over a period of four years. All of the species are reported including environmental relationships of the Orthoptera. Each species represented was studied for variability, and measurements were made for representative specimens. Four of the recognized sub-orders, 9 families, 41 genera, and 60 species and subspecies were collected. An annotated listing is presented. No statistical data was given with reference to possible radiation effects. It was noted that in areas of complete destruction, few Orthopterans are found, perhaps due to the scarcity of vegetation. In geologically disturbed areas large numbers were found and in areas where no nuclear effects were noted, few Orthoptera were present. (BBM) (LE) *Keywords:* invertebrate*, ecology/ecosystem*, taxonomy*

61 **BARR, W.F. 1969. The Buprestidae and Cleridae of the Nevada Test Site (Coleoptera). Great Basin Naturalist Memoirs 24:11-19.**

A preliminary listing of the species and descriptions are given of specimens of beetles belonging to the families Buprestidae and Cleridae. These specimens were collected at the Nevada Test Site between July 2nd and August 2nd in 1960, 1961 and 1962. (FMM) *Keywords*: invertebrate*, taxonomy*

62 **BEATLEY, J.C. 1962. Vascular plants of the U.S. Atomic Energy Commission's Nevada Test Site, Nye County, Nevada. USAEC Report UCLA-508, 33 pp.**

Taxa lists are given for vascular plants of the Nevada Test Site in Nye County, Nevada. Specimens were collected from 1958-1962 and are either included in the general herbarium or as voucher specimens in connection with field study plots. Distribution data given is based on specimens from drainage basins in the test site area. Geographic description of the area is given. (BBM) *Keywords*: vegetation*, ecology/ecosystem*, taxonomy*

63 **BEATLEY, J.C. 1965. Ecology of the Nevada Test Site. I. Geographic and ecologic distributions of the vascular flora (annotated checklist). USAEC Report UCLA 12-553, 69 pp.**

A checklist of vascular plants of the Nevada Test Site is presented for use in studies of plant ecology. Data on the occurrence and distribution of plant species are included. Collections were made from both undisturbed and disturbed sites. (CH) *Keywords:* vegetation*, ecology/ecosystem*, taxonomy*

64 **BEATLEY, J.C. 1965. Ecology of the Nevada Test Site. II. Status of introduced species. USAEC Report UCLA 12-554, 39 pp.**

Bromus rubens, B. tectorum and *Salsola kali* are the most successful introduced alien species of flora on the Nevada Test Site. *Bromus rubens* is now part of undisturbed shrub communities, especially *Coleogyne* at middle elevations, and is abundant on burned areas at middle elevations. *B. tectorum* occurs at higher elevations where it is essentially restricted to disturbed areas. It is actively increasing its areal distributions as an accompaniment of disturbances of the higher elevations. *Salsola kali* is restricted to sites where the physical characteristics of the soil surface have been modified and shrubs killed or inactivated. (TPO) *Keywords:* invasive species*, perturbations*, annual plants*, ecology/ecosystem*

65 **BEATLEY, J.C. 1965. Ecology of the Nevada Test Site. III. Survival of winter annuals, 1963-64. USAEC Report UCLA 12-555, 21 pp.**

Summarizes the survival of winter annuals on the Nevada Test Site in the growing season of 1963-64. Survival varied between 21-63% in Yucca Flat; 10-15% in Jackass Flats; and 40% in Rock Valley. Elimination of the majority of seedlings before reaching maturity was inferred as being a regular phenomenon. Soil moisture regimes following germination were largely responsible for the level of survival reached with species-specific differences noted. (TPO) *Keywords:* soil property*, annual plants*, life history*

66 **BEATLEY, J.C. 1965. Ecology of the Nevada Test Site. IV. Effects of the Sedan detonation on desert shrub vegetation in northeastern Yucca Flat, 1962-65. USAEC Report UCLA 12-571, 55 pp.**

Vegetation and environmental parameters were measured on three sites over three years in the vicinity of the Sedan crater to evaluate the effects of the manipulation on the native flora. The first post-Sedan populations of winter annuals were large and vigorous, which was interpreted as being partly due to "stimulation" effects of ionizing radiation on winter annual embryos. The apparent effects were not seen in later years. Direct effects of radiation on flora were obscured by the multiplicity of environmental factors impinging on the vegetation coupled with non-nuclear sources of damage such as heavy loads of dust. (TPO) *Keywords:* perturbations*, vegetation*, perennial plants*, ecology/ecosystem*, radiation*

67 **BEATLEY, J.C. 1965. Effects of radioactive and nonradioactive dust upon *Larrea divaricata* Cav., Nevada Test Site. In:**

(Hungate, F.P., Ed.) *Radiation and Terrestrial Ecosystems,* Health Physics 11:1621-1625.

Among populations of *Larrea divaricata* Cav., monitored for ionizing radiation exposure following nuclear detonations which occurred in July 1962 at the Nevada Test Site, two also sustained heavy coatings of fine-particle dust. All dust-covered plants eventually became defoliated during the following year; in those irradiated but not dust-coated, there was no defoliation. One of the dusted populations was exposed to 4,000-6,000 roentgens during this year, and the other to negligible dosages; defoliation and subsequent death of stems in the irradiated population was evidently the result, therefore, of dust effects and not the ionizing radiation. Defoliated plants have recovered or are recovering by basal and/or stem sprouts. (Author) *Keywords:* perturbations*, radionuclide inventory*, vegetation*, perennial plants*, ecology/ecosystem*, radiation*

68 **BEATLEY, J.C. 1966. Ecological status of introduced brome grasses (*Bromus* spp.) in desert vegetation of southern Nevada. Ecology 47: 548-554.**

Of the plant species introduced on the Nevada Test Site, Nye County, Nevada, *Bromus rubens* and *B. tectorum* are well established in the present vegetation mosaic. *B. rubens* is frequently the dominant winter annual species in *Coleogyne* (blackbrush) communities at 4000-5000 ft. Relative density (or absence) of populations is a site characteristic, as indicated by quantitative data from 18 study sites in Yucca Flat in the years 1963-1965. Like the native species, it occurs in higher densities on disturbed sites of areas where it is already established in the undisturbed vegetation. Its success is in part due to a growth regime and environmental requirements like those of the native winter annuals, and perhaps to higher percentage survival to maturity as in the 1963-1964 season. It is not aggressive in the region today. *B. tectorum* is confined to disturbed sites at the higher elevations (5,000-7,500 ft) where vegetation is *Artemisia* (sagebrush) or *Artemisia*-Pinyon-Juniper. It is numerically and aerially increasing with an increase in disturbed sites at these elevations. Fire is promoted by both species, but the contribution of *B. rubens* is much greater, either directly or indirectly because it is identified with *Coleogyne* vegetation, the shrub type in the region most susceptible to fire. (Author) *Keywords:* invasive species*, perturbations*, vegetation*, annual plants*, ecology/ecosystem*

69 **BEATLEY, J.C. 1966. *Mirabilis pudica* populations in southern Nye County, Nevada. Leaflets of Western Botany 10:294-296.**

Describes pubescent individuals of *Mirabilis pudica* collected on the Nevada Test Site, and also includes information on distribution and relative abundance. (TPO) *Keywords:* perennial plants*, ecology/ecosystem*, taxonomy*

70 **BEATLEY, J.C. 1966. Winter annual vegetation following a nuclear detonation in the northern Mojave Desert (Nevada Test Site). Radiation Botany 6:6982.**

Winter annual vegetation and environmental phenomena were observed and measured through the growing seasons of 1962-1965, on 3 sites in northeastern Yucca Flat within 2 miles of the Sedan underground thermonuclear detonation in July 1962. Cumulative gamma radiation recorded was of the magnitude of 4,000-13,000 R. As a result of the regional precipitation regime in the autumn of 1962, there were no winter annuals present in the Sedan area, or in most other parts of the Test Site, during the growing season 1962-1963. Seedlings of the first post-Sedan populations, which appeared following September 1963 rains, were the largest and most vigorous of populations observed in any region of the Test Site. The exceptional size and vigor continued through the period of anthesis in May 1964, and were corroborated by measurements of average height, cover, biomass and survival of the spring populations, as compared with those on seven other sites in central and northern Yucca Flat. In the next generation, germinated in the spring of 1965 following record precipitation (4-5 in.), there was neither higher survival of the Sedan populations nor exceptional development at any stage during the several-week growing season. The unusual vigor of the winter annual populations in the 1963-1964 season is inferred to have been in part a "stimulatory" effect of the ionizing radiation to which the embryos in the seeds were exposed from July 1962 until time of germination in September 1963. Abnormal morphological development of frequent individuals of *Chaenactis stevioides*, the dominant winter annual on the Sedan sites, may also have been an effect of seed irradiation. (Author) *Keywords:* annual plants*, ecology/ecosystem*, life history*, radiation*

71 **BEATLEY, J.C. 1967. Ecology of the Nevada Test Site. V. Winter annual survival data. USAEC Report UCLA 12-650,**

36 pp.

Data on survival of winter annual plants of the Nevada Test Site are presented in tabular form for the years 1963-64 and 1964-65. (TPO) *Keywords:* annual plants*, life history*

72 **BEATLEY, J.C. 1967. Survival of winter annuals in the northern Mojave Desert. Ecology 48:745-750.**

Following early autumn germination in Mojave Desert winter annual populations (53 taxa) sampled on 13 plots (total sample size, 16.4 m^2) in three drainage basins in southern Nevada, 1963-1964, there was 38 percent survival to maturity (plot range 10-63 percent). Death occurred in early spring, at the time of shift from the slow vegetative growth of winter to the beginning of stem elongation. Despite no marked precipitation deficiencies during the 7 to 8 month growing season, mortality apparently resulted from inadequate soil moisture to meet the demands of all seedlings at the point in the life cycle of a manyfold increase in plant volume. Mean percentage survival to maturity of seedlings (58 taxa), sampled on 62 plots (total sample size, 62 m^2) in seven drainage basins, following spring germination after rains of 3-5.5 inches in March-April 1965, was 60 percent (range by basin, 44-83 percent). Mortality in these populations, whose life cycles were completed in 6-10 weeks, could not be attributed to inadequate moisture levels. In most seasons, regardless of precipitation regimes, the majority of seedlings of desert annuals probably do not survive to maturity. (Author) *Keywords:* annual plants*, life history*

73 **BEATLEY, J.C. 1969. Biomass of desert winter annual plant populations in southern Nevada. Oikos 20:261-273.**

Biomass of mature desert winter annual populations was measured during three growing seasons, which included the possible extremes in length, in 68 Mojave and Great Basin Desert communities. Precipitation was measured concurrently. Biomass was highly variable from site to site, and season to season. Its site variability was related primarily to local edaphic variables and was usually not correlated with the shrub dominants of the site; seasonal variations were related, directly or indirectly, to the rainfall regimes. Values ranged from 0 to 616 kg/ha on sites with undisturbed soils, and seasonally were 2 to 5 times higher on burned sites than on comparable unburned sites in the same area. Maximum site value was 753 kg/ha, obtained on a burned site where most of the weight was due to high density of *Bromus rubens L*., an introduced grass species. Although in two of the three years averaged site values were similar, the biomass was overall the greatest in the 38 Mojave Desert communities, least in the 10 Great Basin Desert communities, and intermediate (if large contributions of *Bromus* on about half the sites are excluded) in the 20 communities considered transitional between the two desert regions. (Author) *Keywords:* climate*, perturbations*, invasive species*, annual plants*, ecology/ecosystem*

74 **BEATLEY, J.C. 1969. Dependence of desert rodents on winter annuals and precipitation. Ecology 50:721-724.**

Winter annual parameters, post-reproduction rodent densities, and precipitation, were recorded over 5 consecutive years, 1963-1968, on 15 sites in Jackass Flats, southern Nevada. When the rain critical to autumn germination came, winter annuals were present during autumn-to-spring, and there was spring reproduction in the rodents (as indicated by summer densities). When the critical rain failed to come, winter annual populations were negligible and the rodents did not reproduce in the spring. One season, half of the study sites received autumn rainfall adequate for germination, and the other half did not; summer rodent densities increased on the former and markedly decreased on the latter. Following extraordinarily heavy early spring rains, following an autumn essentially without rain, there was partially successful germination in early spring, and rodent reproduction occurred in the summer. It is concluded that occurrence and failure of reproduction in desert rodents are correlated with the presence and absence of winter annuals in the environment. The data suggest that dietary water (and vitamins), available in winter annual vegetation prior to or at time of onset of the breeding season, are requirements in the physiology of reproduction of heteromyid species. (Author) *Keywords:* climate*, annual plants*, mammal*, ecology/ecosystem*, life history*

75 **BEATLEY, J.C. 1969. Vascular plants of the Nevada Test Site, Nellis Air Force Range, and Ash Meadows. USAEC Report UCLA 12705, 122 pp.**

A compilation is presented of the vascular plants of the Nevada Test Site, Nellis Air Force Range and Ash Meadows. The plants are classified according to phyla, namely Pterophyta (ferns), Coniferophyta (cone-bearing plants), and Anthophyta (flowering plants. The Coniferophyta and Anthophyta are subclassified into families, genus and species. Details are given of the geographical and ecological distribution. *Keywords:* wetlands*, vegetation*, ecology/ecosystem*, taxonomy*

76 **BEATLEY, J.C. 1970. Perennation in *Astragals lentiginosus* and *Tridens pulchellus* in relation to rainfall. Madrono 20:326-332.**

Following large germinations related to heavy spring rains in 1965, numbers of plants of *Astragalus lentiginosus* Dougl. var. *fremontii* (Gray) Wats. (Leguminosae) and *Tridens pulchellus* (HBK.) Hitchc. (Gramineae) were recorded during 2 or more consecutive years on study sites in the northern Mojave Desert of southern Nevada (Nevada Test Site). Numbers of *Astragalus* plants surviving after the first year were correlated with increased rainfall with increase in elevation (from almost no plants at 3,800 ft to nearly all at 4,800 ft). The large reproducing populations of this species in southern Nevada appear to be biennials with origins related to exceptional spring rains, and the perennial habit is restricted to higher elevation populations and only certain individuals at the lower elevations. Most *Tridens* plants behaved as annuals, with only a few persisting as perennials. The facultative life cycle appears to contribute to the seasonal success of desert herbaceous species in which it occurs, and enables them to belong to a diversity of communities over a wide range in elevation. (NFG) *Keywords:* climate*, annual plants*, perennial plants*, life history*

77 **BEATLEY, J.C. 1971. Ecologic and geographic distributions of the vascular plants of southern Nye County, and adjacent parts of Clark, Lincoln, and Esmeralda Counties, Nevada (Supplement to UCLA 12-705). USAEC Report UCLA 12-800, 49 pp.**

A compilation is presented of the vascular plants of southern Nye County and adjacent parts of Clark, Lincoln and Esmeralda Counties in Nevada. The plants were collected in the 1969 and 1970 seasons and are classified according to phyla viz: Calamophyta (horsetails), Lepidophyta (clubmosses), Pterophyta (ferns), Coniferophyta (cone-bearing plants), and Anthophyta (flowering plants). They are then subclassified into families, genus and species and the ecological and geographic distribution are noted. (FMM) *Keywords:* vegetation*, ecology/ecosystem*, taxonomy*

78 **BEATLEY, J.C. 1971. Vascular plants of Ash Meadows, Nevada. USAEC Report UCLA 12-845, 59 pp.**

Presents an annotated listing of 188 vascular plant taxa collected by Beatley and Reveal in 1968-1971 at Ash Meadows, southern Nye County, Nevada, and adjacent Inyo County, California. Endemics and species with restricted distributions in the region are discussed, aiding future discussions of threatened and endangered species of plants. (TPO) *Keywords:* wetlands*, sensitive plants*, vegetation*, taxonomy*

79 **BEATLEY, J.C. 1973. Check list of vascular plants of the Nevada Test Site and central-southern Nevada. USAEC Report C00-2307-4, 42 pp.**

The compilation of taxa of vascular plants begun in 1959 in central-southern Nevada and the Nevada Test Site has been almost completed. A check list has been published, but a few taxa remain to be described, and a number of collections are yet to be critically reviewed. Species collected on the Test Site are indicated by an asterisk. Of a total of 1,107 taxa, 706 occur within or near the boundaries of the Test Site. (BBM) *Keywords:* vegetation*, taxonomy*

80 **BEATLEY, J.C. 1973. Russian-thistle *(Salsola)* species in western United States. Journal of Range Management 26:225-226.**

This paper poses the thesis that Russian thistle populations are either *Salsola iberica, S. paulsenii* or a combination of both rather than a single species *Salsola pestifer* A. Nels. (or *salsola kali L.*). (TPO) *Keywords:* vegetation*, invasive species*, annual plants*, ecology/ecosystem*, taxonomy*

81 **BEATLEY, J.C. 1974. Effects of rainfall and temperature on the distribution and behavior of *Larrea tridentata* (creosote-bush) in the Mojave Desert of Nevada. Ecology 55:245-261.**

The effects of rainfall and temperature on the distribution and certain behavioral characteristics of *Larrea tridentata* (creosote bush) at and near its northern limits in the northern Mojave desert of southern Nevada, were investigated at 30 sites with *Larrea* and 20 sites without *Larrea* in eight drainage basins at elevations of 915 - 1,770 m over a 2,600-km^3 area of the Nevada Test Site. Data used were (1) rainfall records for 9 years (1963-71) for each site; (2) maximum and minimum air temperature records for each site, Nov. 1962-Feb. 1972; (3) percentage cover by all shrub species and by *Larrea*; (4) height and density data for *Larrea*; and (5) percentage of germinable seeds from 29 of the *Larrea* populations for three seasons

(1963-65) in relation to the seasonal rainfall for each site. Total percentage cover by all shrub species is highly correlated with mean annual rainfall, less well correlated with elevation. In general, in undisturbed communities, the taller the *Larrea* plants the fewer there are of them, but the relationship is not strictly linear. Using height as an index to plant volume, numbers of *Larrea* plants are highly correlated with total plant volume. Mean height is not strongly correlated with mean annual rainfall or temperature parameters, but is well correlated with the ratio of mean precipitation mean temperature. The prevailing low minimum air temperatures and their extremes in the lowlands of enclosed drainage basins are inferred to be the primary cause of the absence of *Larrea* in three discrete vegetation zones. Average extreme minimum air temperatures on all *Larrea* sites were above 1 degree F; the absolute minimum was -8 degrees F. Upper altitudinal limits of *Larrea* apparently are not determined by minimum temperatures. There is no pattern of relationship between maximum temperatures and the distribution of *Larrea* although the highest extreme maxima usually occur on non-*Larrea* sites in the lowlands of Frenchman Flat. Mean annual rainfall on the *Larrea* sites ranged from 118 to 183 mm. Altitudinal and latitudinal limits of *Larrea* coincide with a maximum mean rainfall of 183 mm. Mean annual rainfall of 160-183 mm appears to be critical to the behavior of *Larrea*. Germination trials support the inference of a deleterious effect on high rainfall on *Larrea* populations through time: there were high correlation coefficients (negative or positive, depending on the year) between the rainfall of the effective rainfall season and the percentage of germinable seeds; highest mean germination percentages (20%-60%) occurred with 80-150 mm of seasonal rain, and either lower or higher seasonal rainfall resulted in lower percentages of germinable seeds (0%-20%). (Author) *Keywords:* climate*, vegetation*, perennial plants*, ecology/ecosystem*, life history*

82 BEATLEY, J.C. 1974. Phenological events and their environmental triggers in Mojave Desert ecosystems. Ecology 55:856-863.

Phenological events in Mojave desert systems are triggered by heavy rains (greater than 25 mm [1 in]). The most predictable and consequential of these is a regional rain between late Sept. and early Dec. This rainfall event is usually the precursor of successful vegetative and reproductive growth of shrubs the next spring, and is usually necessary for all growth phenomena of herbaceous perennials and winter annuals during the following winter and spring. For most plant components in most years, the growing season is synchronized within the autumn-winter-spring period, and the relative biological success each spring is dependent upon the occurrence or failure of occurrence of events of the preceding autumn. Under certain conditions rainfall during other seasons may trigger growth and reproduction of the primary producers and permit at least moderate or local successes every season. The relationships are stated in a flow diagram for the rainfall and phenological events, as documented for 13 years in the Mojave desert of southern Nevada. (Author) *Keywords:* climate*, vegetation*, annual plants*, perennial plants*, ecology/ecosystem*, life history*

83 BEATLEY, J.C. 1975. Climates and vegetation pattern across the Mojave/Great Basin Desert transition of southern Nevada. Amer. Midland Nat. 93:53-70.

Plant communities of the transition between the Mojave and Great Basin desert of southern Nevada are under the primary control of climatic variables. Rainfall increases and temperature decreases according to large increments of increase in elevations of the drainage basins from S to N. Within the basins, the climates and vegetation patterns are primarily under the control of patterns of air circulation and nocturnal cold air accumulations and secondarily, of edaphic factors. Minimum temperature and maximum mean rainfall tolerances of Mojave Desert *Larrea* (creosote bush) communities are exceeded across this transition as, apparently, are the mean maximum temperature and minimum rainfall tolerances of the Great Basin *Artemisia* (sagebrush) communities. In those communities which characterize the transition (*Coleogyne*, *Grayia-Lycium andersonii*, *Lycium pallidum-Grayia*, *Lycium shockleyi*), the Mojave and Great Basin temperature and rainfall regimes occur in various definable combinations. Only *Atriplex confertifolia* (shadscale) communities cannot be so defined; these occur along topographic gradients in both Mojave and Great Basin Desert climates. (Author) *Keywords:* climate*, vegetation*, ecology/ecosystem*

84 BEATLEY, J.C. 1976. Environments of Kangaroo Rats (Dipodomys) and Effects of Environmental Change on Populations in southern Nevada. Journal of Mammalogy. Vol. 57 (No. 1):67-93.

Climates and plant components of environments of the heteromyid rodents *Dipodomys merriami*, *D. microps*, and *D. deserti* are characterized and compared on sites over 2,600 square kilometers in central-southern Nevada. Sites compared are those with the 20 highest-density populations each of *D. merriami* and *D. microps*, and all sites with *D. deserti*, from among 58 undisturbed communities where rodent numbers were established by five consecutive years of censusing. The study areas were in eight drainage basins of the Nevada Test Site, at elevations of 915 to 1,850 meters (m), and included Mojave, Great Basin, and transition desert systems. Other parameters measured on each site, and compared for the site groups, are rainfall, maximum and minimum air temperatures, and various parameters for all plant components of the systems. Plant data were collected seasonally with the rodent data, whereas the climatic data were for 10 years. Distributions of *D. merriami* and *D deserti* were correlated with the low shrub cover and low mean precipitation/mean temperature (P/T) ratios of the Mojave Desert *Larrea* communities. Distributions and higher densities of *D. microps* were closely correlated with the high shrub cover and high P/T ratios of the *Coleogyne* and *Grayia-Lycium* communities of the transition, and *Artemisia* of the Great Basin Desert. On the compared sites either *D. merriami* or *D. microps* usually occurred to the near exclusion of the other, and none of the plant parameters other than percentage shrub cover distinguished the two rodent environments. Restriction of *D. microps* to environments with high mean rainfall supports recent physiological evidence by others that this species may have the highest body-water turnover rate and lowest urine-concentrating ability in the genus. On nine other sites shrub cover had been destroyed (and surface soils modified) by nuclear detonations, fire, or blading prior to the measurements period. Three of the sites were in declining ionizing-radiation fields. Regardless of nature of origin of the disturbance, there was a rapid and usually nearly complete replacement of *D. microps* by large *D. merriami* populations following the disturbance. The only change in plant parameters consistent among the sites was the large reduction in shrub cover. Occupancy of these sites by *D. merriami* was in accord with its ability to live with low shrub cover. Disappearance of *D. microps* was evidently related to its corresponding requirement of high shrub cover, suggesting a vulnerability to elimination by predators where there are few or no shrubs in the environment. (Author) *Keywords:* climate*, vegetation*, perturbations*, perennial plants*, mammal*, ecology/ecosystem*

85 **BEATLEY, J.C. 1976. Rainfall and Fluctuating Plant Populations in Relation to Distributions and Numbers of Desert Rodents in Southern Nevada. Oecologia 24:21-42.**

Fluctuations in rainfall and size of desert rodent and plant populations for each of five consecutive years were documented on 68 sites in Mojave, Great Basin, and transition desert communities of central-southern Nevada. Post-reproduction rodent densities in the summer usually followed the seasonal patterns of winter annual success the previous spring, in turn directly related to the success of germination the preceding autumn. In the "*Dipodomys merriami* environment", at the lower elevations with relatively low rainfall and high temperatures of the Mojave Desert, *D. merriami* and *D. deserti* numbers (indicating success or failure of reproduction) closely followed the seasonal and site patterns of winter annual success. In the "*Dipodomys microps* environment", at the middle and higher elevations with the relatively high rainfall and lower temperatures of the transition and Great Basin deserts, *D. microps* numbers followed winter annual success patterns in years of high or low rainfall in the months preceding reproduction, but there was reproduction in years of intermediate rainfall whether or not there were winter annuals in the environment. Reproductive patterns of *D. merriami* in the "*D. microps* environment" followed those of *D. microps. Perognathus longimembris*, the ubiquitous heteromyid of the region, also exhibited both reproductive patterns, depending on whether it was in the "*D. merriami*" or the "*D. microps* environment." The Mojave Desert *P. formosus*, edaphically restricted in the region, followed the patterns of the "*D. merriami* environment" and its numbers were highly correlated with winter annual success. Herbaceous perennials, capable of large germinations of plants behaving as biennials or winter annuals, are shown to have large effects on *D. merriami* numbers. Size of populations of Eurasian annual species of *Bromus* and *Salsola* were not correlatable with rodent reproduction patterns. From all patterns in all environments, it is inferred that environmental conditions affecting water balance in the rodents play the key role in initiation of reproduction. Environmental moisture levels during the winter season are usually under the control of rainfall of late autumn-early winter, coincidentally the period of greatest predictability of heavy rains. The herbaceous plants, present in the winter months most years, are available sources of water (and vitamins) at the time of initiation of reproductive activity. For *D. microps*, identified with the mesic environments of the region, the herbaceous plants may or may not be necessary sources of water for reproduction, depending on the seasonal rainfall regime. For *D. merriami*, herbaceous plants appear to serve as a water reservoir required for reproduction in its usual environments. The same relationships evidently obtain for the other heteromyids, and the cricetids as a group. (Author) *Keywords:* climate*, vegetation*, invasive species*, annual plants*, perennial plants*, mammal*, ecology/ecosystem*

86 **BEATLEY, J.C. 1976. Vascular Plants of the Nevada Test Site and Central-Southern Nevada. TID-26881, N.T.I.S. U.S. Dept of Commerce. Springfield, VA, pp. 308.**

A compilation is presented of the vascular plants of the Nevada Test Site and adjacent parts of Nye, Clark, Lincoln, and Esmeralda counties. 1,093 plant taxa in 98 families are included from collections begun by the author in 1959 along with information on their ecological and geographical distributions. The characteristic physiography, geology, soil types, and climatic patterns for the region are defined. Vegetation types and associations for the Mojave, Transition, and Great Basin deserts are distinguished according to the physiographic features with which they are associated. Lists of the dominant annual and perennial species for each vegetation types are presented. Information on introduced and threatened and endangered species is included. (EC) *Keyword:* climate*, geology*, soil property*, invasive species*, sensitive plants*, vegetation*, ecology/ecosystem*, taxonomy*

87 BEATLEY, J.C. 1977. Endangered Plants Species of the Nevada Test Site, Ash Meadows, and Central-Southern Nevada. U.S. Energy Research and Development Administration. COO-2307-11, 77 pp.

A total of 15 vascular plant taxa currently appearing on the "Endangered Species list" for southern Nevada and adjacent California are described. Plant collection locations and distributions are provided. Areas that are recommended as critical habitat are identified. (WKO) *Keywords:* sensitive plants*, wetlands*, ecology/ecosystem*, taxonomy*

88 BEATLEY, J.C. 1977. Addendum to COO-2307-11 and COO-2307-12 (Endangered and Threatened Plants Species of the Nevada Test Site, Ash Meadows, and Central-Southern Nevada). U.S. Energy Research and Development Administration. COO-2307-13, 9 pp.

Two additional vascular plant taxa, *Ephedra funerea* and *Mirabilis pudica*, currently appearing on the 1975 Federal Register for Threatened and Endangered Species for southern Nevada and adjacent California which were omitted in the initial reports are discussed. Plant collection locations and distributions are provided. Areas that are recommended as critical habitat are identified. (WKO) *Keywords:* sensitive plants*, wetlands*, ecology/ecosystem*, taxonomy*

89 BEATLEY, J.C. 1977. Threatened Plants Species of the Nevada Test Site, Ash Meadows, and Central-Southern Nevada. U.S. Energy Research and Development Administration. COO-2307-12, 67 pp.

A total of 23 vascular plant taxa currently appearing on the 1975 Federal Register for Threatened and Endangered Species for southern Nevada and adjacent California are described. Plant collection locations and distributions are provided. Areas that are recommended as critical habitat are identified. (WKO) *Keywords:* sensitive plants*, wetlands*, ecology/ecosystem*, taxonomy*

90 BEATLEY, J.C. 1979. Shrub and Tree Data for Plant Associations Across the Mojave/Great Basin Desert Transition of the Nevada Test Site, 1963-1975. U.S. Department of Energy. DOE/EV/2307-15, 52 pp.

The shrub, tree, and cactus vegetation of 59 selected study sites in eight drainage basins of the Nevada Test Site was documented in 1963, and again in 1975, by 1,100 ft of modified line interception data on each site, each year. Vegetation of the sites, which span the range of 3,076 to 7,425 ft elevation, is assigned to five plant associations, and intergrades, on the 25 Mojave Desert sites; eight associations on the 10 Great Basin Desert sites; and six associations, and ecotonal types, on the 24 sites of the desert transition. All of the sampled vegetation is considered to be climax. The data presented are for numbers of plants crossing the lines, mean height of plants, and calculated percentage cover of the ground. Apparent from the data are increases in the numbers, height, and percentage cover on nearly all sites, and in essentially all species, during the 12-year period, and a decrease in the proportions of dead plants. The increases appear to be directly related to rainfall during the time interval. (Author) *Keywords:* climate*, perennial plants*, ecology/ecosystem*

91 BEATLEY, J.C. 1980. Fluctuations and Stability in Climax Shrub and Woodland Vegetation of the Mojave, Great Basin and Transition Deserts of Southern Nevada. Israel Journal of Botany. Vol 28:149-168.

Woody vegetation was documented over a 12-year period, and rainfall through 10 years of the period, in 56 climax shrub and woodland communities in the Mojave, Great Basin and transition deserts of the Nevada Test Site in southern Nevada. Line interception data (335 m) were collected in each community in 1963, during a period of below-average rainfall, and again in 1975 along the same sampling lines, by the same method and observer. From summaries of the data for all sites and from data for individual sites, at the end of the 12 years which included periods of unusually high rainfall, there were consistent increases in numbers of shrubs and trees, mean height and percentage cover, and decreases in proportions of dead plants in the populations; but, neither the qualitative species composition nor the relative proportions of the species changed. From plant-by-plant comparisons along the lines of nine representative sites, it is evident that most of the shrubs and trees living in 1963 were still present as living plants in 1975 and an average 14% were dead or had disappeared from the lines by 1975; around 20% to 30% of the 1975 plants were new to the lines and of seedling or, in some species, shoot origin. From the data it is predictable that during the recurring dry/moist cycles in desert regions there is a high rate of turnover in the shrub component of the climax vegetation. Plant fluctuations were closely correlated with regional and site rainfall fluctuations of the period. The magnitude of the fluctuations was within the range necessary for continuing stability of all of the communities and populations of woody species in the three desert areas. (Author) *Keywords:* climate*, perennial plants*, ecology/ecosystem*

92 **BECHTEL NEVADA. 1998. Nevada Test Site Routine Radiological Environmental Monitoring Plan. DOE/NV/11432–244, Bechtel Nevada, Las Vegas, NV.**

This Routine Radiological Environmental Monitoring Plan (RREMP) addresses compliance with DOE Orders 5400.1 and 5400.5 and other drivers requiring routine effluent monitoring and environmental surveillance on the NTS. This monitoring plan addresses the activities conducted onsite NTS under the Final Environmental Impact Statement and Record of Decision (EIS) (1996a). This plan brings together sitewide environmental surveillance; site-specific effluent monitoring; and operational monitoring conducted by various missions, programs, and projects.on the NTS. The plan provides an approach to identifying and conducting routine radiological monitoring at the NTS, based on integrated technical, scientific, and regulatory compliance data needs. This plan identifies the requirements for radiologic monitoring on and off the NTS and at associated facilities under Necessary and Sufficient Standards identified in 1997, including DOE Orders, state and federal regulations, and stakeholder issues. The monitoring plan focuses on .the need to ensure that the public and the environment are protected, that compliance with the letter and the spirit of the law is achieved, and that good land stewardship is practiced. The monitoring plan uses a decision-based approach to identify the environmental data that must be collected and provides Quality Assurance, Analysis, and Sampling Plans (QAASPs) which ensure that defensible data is generated. The approach is based on a modification of the U.S. Environmental Protection Agency's (EPA) Data Quality Objective (DQO) process, a seven step process that calls for identification of the decisions that data collection activities must support, and uses a logical structure to develop the plan for data collection and analysis. The plan provides one central, integrated approach for routine radiological monitoring, sitewide, on and off the NTS and also at associated DOE facilities including the North Las Vegas Facility (NLVF), the Remote Sensing Laboratory, the Special Technologies Laboratory (STL), Los Alamos Operations, and Washington Aerial Measurements Operations (WAMO). The plan is organized into seven sections: introduction, a description of the site conceptual model and sources of radiation with the potential to affect public health and the environment at the NTS, drivers requiring routine radiological environmental monitoring, a summary description of integrated plans to monitor the five media in the environment onsite and offsite (air, water, soils, plants, and animals), a description of operational monitoring requirements, a summary of a conceptual plan for data management, and a description of how this plan relates to other environmental monitoring activities on the NTS. In the appendices, detailed QAASPs for air, water, and biota monitoring are presented. A subsequent appendix summarizes the DQO process used for each of the five media. The last appendix presents a checklist for use in developing vadose zone monitoring Sampling and Analysis Plans (SAPs). (Authors) *Keywords*: management*, radionuclide inventory*, hydrology*, soil property*, vegetation*, bird*, mammal*, radiation*

93 **BECHTEL NEVADA. 1998. Ecological Monitoring and Compliance Program Fiscal Year 1998 Report. DOE/NV/11718–255, Bechtel Nevada Ecological Services, Las Vegas, NV, 58 pp.**

The Ecological Monitoring and Compliance program, funded through the U.S. Department of Energy, Nevada Operations Office, monitors the ecosystem of the Nevada Test Site (NTS) and ensures compliance with laws and regulations pertaining to NTS biota. This report summarizes the program's activities conducted by Bechtel Nevada (BN) during fiscal year 1998. Twenty-one sites for seven projects were surveyed for the presence of state or federally protected species. Three projects were in or near habitat of the threatened desert tortoise and required special clearance and transect surveys. Northern NTS was partitioned into ecological landform units using aerial photographs and ground-truthing surveys. Vegetation and habitat data were collected at 550 ecological landform units, completing habitat mapping of the NTS. Surveys were completed which identify the NTS distribution and range of Clokey's eggvetch, a candidate plant for listing under the Endangered Species Act. Field surveys verified that the Blue Diamond cholla, a candidate plant, does not occur on the NTS. Sitewide inventories were conducted for the western burrowing owl, six bat species, wild horses, and raptor nests. Surveys verified that burrowing owls, which are known to migrate, occur year-round on the NTS and that the small-footed myotis bat occurs on the NTS. Maps showing the revised distribution and range of these plants and animals on the NTS are presented. Wetlands and man-made water sources were monitored for wildlife use, and three new springs were discovered. A revised map showing the 28 known natural water sources of the NTS is presented. Three chemical spill test plans were reviewed for their potential to impact biota downwind of spills on Frenchman Lake playa. All geospatial data collected were entered into Bechtel Nevada's Ecological Geographic Information System for use in ongoing ecosystem management of the NTS. (Authors) *Keywords:* perturbations*, desert tortoise*, sensitive animals*, sensitive plants*, wetlands*, vegetation*, bird*, reptile*, mammal*, ecology/ecosystem*

94 **BECHTEL NEVADA. 1999. Ecological Monitoring and Compliance Program Fiscal Year 1999 Report. DOE/NV/11718–387, Bechtel Nevada Ecological Services, Las Vegas, NV, 61 pp.**

The Ecological Monitoring and Compliance program, funded through the U.S. Department of Energy, Nevada Operations Office, monitors the ecosystem of the Nevada Test Site (NTS) and ensures compliance with laws and regulations pertaining to NTS biota. This report summarizes the program's activities conducted by Bechtel Nevada during fiscal year 1999. Program activities included: (1) biological surveys at proposed construction sites, (2) desert tortoise compliance, (3) ecosystem mapping, (4) sensitive species and unique habitat monitoring, and, (5) biological monitoring at the HAZMAT Spill Center. Biological surveys for the presence of sensitive species were conducted at 25 sites for 21 NTS projects. Thirteen sites were in desert tortoise habitat, and 56 acres of tortoise habitat were disturbed. No tortoises were harmed or displaced from project sites. A habitat map of major shrubland and woodland alliances on the NTS was developed based on analysis of vegetation data from over 1,500 ecological landform units. A topical report and Geographic Information System produced map describing the known NTS distribution of Clokey's eggvetch, a candidate plant for listing under the Endangered Species Act, was published. Sitewide inventories were conducted for the western burrowing owl, six bat species, wild horses, raptor nests, and mule deer. Sixty-four known owl burrows were monitored. Forty of the burrows are in disturbed habitat. Burrows being used by owls were present in at least two of the three eco-regions of the NTS (Mojave Desert, Transition Region, Great Basin Desert) from November through August. Seven different breeding pairs of owls were detected, and young owls were detected at four burrows in the Transition Zone and three burrows in the Great Basin Desert eco-region. Forty-six bats, representing five bat species of concern, were captured in mist-nets at water sources in the Great Basin Desert eco-region. Four bat species of concern were detected with the Anabat II call-recording system at selected tunnel and mine entrances verifying that some NTS mines and tunnels are used as bat roosts. Thirty-one adult horses and five foals were counted this year. None of the 13 foals observed annually between 1995 - 1998 have survived. Four natural water sources and one man-made pond were used by horses in the summer. Only five active raptor nests were detected this year, compared to 12 observed last year. A spotlighting survey for mule deer was conducted over three consecutive nights and 1.2 deer/10 kilometers was the mean sighting rate. Selected wetlands and man-made water sources were monitored for physical parameters and wildlife use. Large flocks of mourning doves were noticeably absent this year at springs and sumps. Four coyotes drowned in a plastic-lined sump at ER-20-6 in Area 29. Five new water sources discovered last year were visited to determine if they qualify as jurisdictional wetlands. Three of these, Wildhorse Seep, Little Wildhorse Seep, and Wahmonie Seep #4, possess all three indicators of jurisdictional wetlands. Chemical spill test plans for six experiments at the HAZMAT Spill Center were reviewed for their potential to impact biota downwind of spills on Frenchman Lake playa. (Authors) *Keywords:* perturbations*, desert tortoise*, sensitive animals*, sensitive plants*, wetlands* vegetation*, bird*, reptile*, mammal*, ecology/ecosystem*, life history*

95 **BECHTEL NEVADA. 2000. Ecological Monitoring and Compliance Program Fiscal Year 2000 Report. DOE/NV/11718–484, Bechtel Nevada Ecological Services, Las Vegas, NV, 61 pp.**

The Ecological Monitoring and Compliance program, funded through the U.S. Department of Energy, Nevada Operations Office, monitors the ecosystem of the Nevada Test Site (NTS) and ensures compliance with laws and regulations pertaining to NTS biota. This report summarizes the program's activities conducted by Bechtel Nevada during fiscal year 2000. Program activities included: (1) biological surveys at proposed construction sites, (2) desert tortoise compliance, (3) ecosystem mapping, (4) sensitive species and unique habitat monitoring, and (5) biological monitoring at the HAZMAT Spill Center. Biological surveys for the presence of sensitive species were conducted for 24 NTS projects. Seventeen sites were in desert tortoise habitat, and six acres of tortoise habitat were documented as being disturbed this year. No tortoises were found in or displaced from project areas, and no tortoises were accidentally injured or killed. A topical report describing the classification of habitat types on the NTS was completed. The report is the culmination of three years of field vegetation mapping and the analysis of vegetation data from over 1,500 ecological landform units. A long-term monitoring plan for important plant species that occur on the NTS was completed. Sitewide inventories were conducted for the western burrowing owl, bat species of concern, wild horses, raptor nests, and mule deer. Fifty-nine of 69 known owl burrows were monitored. Forty-four of the known burrows are in disturbed habitat. As in previous years, some owls were present year round on the NTS. An overall decrease in active owl burrows was observed within all three ecoregions

(Mojave Desert, Transition, Great Basin Desert) from October through January. An increase in active owl burrows was observed from mid-March to early April. A total of 45 juvenile owls was detected from eight breeding pairs. One nest burrow was detected in the Mojave Desert, one in the Great Basin Desert, and six in the Transition ecoregion. Seventy bats, representing four bat species of concern, were captured in mist-nets at water sources in the Great Basin Desert ecoregion. Bats were detected with the Anabat II call-recording system at selected tunnel and mine entrances verifying that some NTS mines and tunnels are used as bat roosts. Thirty-seven adult horses and 11 foals were counted this year. Four of the five foals observed last year have survived to yearlings. A monitoring plan for NTS horses was completed. Six active red-tailed hawk nests and 10 nestling red-tailed hawks were detected this year. Two spotlighting surveys for mule deer were conducted, each over three consecutive nights in October 1999 and August 2000. The mean sighting rate in October was 1.2 deer/10 kilometers (km) and 1.6 deer/10 km in August. Selected wetlands and man-made water sources were monitored for physical parameters and wildlife use. No dead animals were observed this year in any plastic-lined sump. Pahute Mesa Pond was confirmed to have vegetation, hydrology, and soil indicators that qualify the site as a jurisdictional wetland. The chemical spill test plan for one experiment at the HAZMAT Spill Center was reviewed for its potential to impact biota downwind of spills on Frenchman Lake playa. (Authors) *Keywords:* perturbations*, desert tortoise*, sensitive animals*, sensitive plants*, wetlands*, vegetation*, bird*, reptile*, mammal*, ecology/ecosystem*, life history*

96 **BECHTEL NEVADA. 2001. Adaptive Management Plan for Sensitive Plant Species on the Nevada Test Site. DOE/NV/11718–507, Bechtel Nevada Ecological Services, Las Vegas, NV, 9 pp.**

The Nevada Test Site supports numerous plant species considered sensitive because of their past or present status under the Endangered Species Act and with federal and state agencies. In 1998, the U.S. Department of Energy, Nevada Operations Office (DOE/NV) prepared a Resource Management Plan which commits to protect and conserve these sensitive plant species and to minimize cumulative impacts to them. This document presents the procedures of a long-term adaptive management plan which is meant to ensure that these goals are met. It identifies the parameters that are measured for all sensitive plant populations during long-term monitoring and the adaptive management actions which may be taken if significant threats to these populations are detected. This plan does not, however, identify the current list of sensitive plant species known to occur on the NTS. The current species list and progress on their monitoring is reported annually by DOE/NV in the Resource Management Plan. (Authors) *Keywords:* management*, sensitive plants*

97 **BECK, D.E., and D.M. ALLRED. 1966. Siphonaptera (fleas) of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 7(2), 27 pp.**

For each of the 33 species of fleas collected at the Nevada Test Site, this sequence in presentation of information was followed: (a) specific and subspecific identity and other pertinent taxonomic data; (b) ecological and geographical distribution with maps; (c) host association; and (d) seasonal occurrence accompanied by graphs where sufficient populations made such presentation worthwhile. Seasonal occurrence was interpreted on the basis that a collection of fleas from a single host constituted an encounter, regardless of the number of fleas taken. For those species for which data are minimal, the presentations are given as summary statements without headings. (Authors) *Keywords:* invertebrate*, ecology/ecosystem*, life history*, taxonomy*

98 **BECK, D.E., and D.M. ALLRED. 1966. Tingidae, Neididae (Berytidae) and Pentatomidae of the Nevada Test Site. Great Basin Naturalist Memoirs 26: 9-16.**

Collections of Tingidae, Pentatomidae, and Neididae were made at the Nevada Test Site as a continuation of the environmental survey of the area. Classification into genus and species was made and relationships to host plants were presented. (BBM) *Keywords:* invertebrate*, vegetation*, ecology/ecosystem*, taxonomy*

99 **BECK, D.E., and D.M. ALLRED. 1968. Faunistic inventory -- BYU ecological studies at the Nevada Test Site. Great Basin Naturalist Memoirs 28: 132-141.**

Ecological studies of the Nevada Test Site were conducted by Brigham Young University from 1959 until termination of the project in 1966. The main objective of the studies was to make a faunistic inventory of the site, and an extensive collection of specimens was made. A taxonomic inventory of fauna collected at the site and location of specimens is presented for Insecta, Araneida, Reptilia, Aves, and Mammalia. Total number of specimens, completely or partly identified, the number of specimens unidentified and available, and specialists working with particular taxonomic groups are tabulated for each family. A list of depositories for Nevada Test Site specimens is given. (BBM) *Keywords:* bird*, reptile*, mammal*, invertebrate*, taxonomy*

100 BECK, D.E., D.M. ALLRED, and E.P. BRINTON. 1963. Ticks of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 4(1), 11 pp.

As part of a study to determine kinds, population, seasonal occurrence, and geographical and ecological distribution of ticks in areas where nuclear detonations have taken place compared with undisturbed areas, the tick fauna of the Nevada Test Site is reported. Twenty four species of animals (primarily rodents and leporids) were found infested with eleven species of ticks. Collections were confined to the valleys and lower elevations of the mesas and mountains. Each type of tick was discussed in relation to its host, seasonal incidence, and associated plant community type. Comments on abundance, presence on unusual hosts, and stage of development are included. Results indicated that the nature of the habitat was influential on survival of the ticks when not on a host. (ST) *Keywords:* invertebrate*, mammal*, ecology/ecosystem*, vegetation*, life history*, taxonomy*, radiation*

101 BECK, D.E., D.M. ALLRED, J.R. MURDOCK, C.D. JORGENSEN, C.L. HAYWARD, and W.W. TANNER. 1964. Nevada Test Site desert ecology. In: Proceedings of the Utah Academy of Sciences, Arts and Letters 41: 202-210.

The major plant communities in the Nevada Test Site and their predominant animal associates were defined. In each community, analyses of the plant, animal and soil relationships were made, with special reference to mammal populations. A study of the structure and complex interactions of the biotic components within areas disturbed by nuclear detonations has begun and a summary is given of the bird, arthropod and herpetological studies. (FMM) *Keywords:* soil property*, vegetation*, invertebrate*, bird*, reptile*, mammal*, ecology/ecosystem*

102 BEHNKE, J.J., and G.B. MAXEY. 1969. An empirical method for estimating monthly potential evapotranspiration in Nevada. Journal of Hydrology 8:418-430.

Monthly potential evapotranspiration values were obtained for several stations throughout the State of Nevada using the Thornthwaite and Olivier equations. The Olivier equation correlated well with lysimeter and adjusted pan data as an estimate of ET. On an annual basis the Thornthwaite equation was approximately 50% too low. A technique was developed to estimate wet bulb depression from temperature data. This made it possible to solve the Olivier equation using only temperature data as input. Climatic conditions in Nevada were such that it was possible to apply the dry adiabatic lapse rate to a centrally located base station to obtain temperature values for other locations lacking climatic data. On a monthly basis, this 'modified' Olivier equation correlated satisfactorily with the original equation for Nevada locations ranging in elevation from 2,171 to 5,136 ft and in latitude from 36° to 41° N. (Authors) *Keywords:* climate*, hydrology*, methods*

103 BERNSTEIN, R.A. 1971. The ecology of ants in the Mojave Desert: their interspecific relationships, resource utilization and diversity. Ph.D. Dissertation, University of California Los Angeles, 142 pp.

The density of colonies of seed-eating ants was sampled for nine areas in the Mojave Desert, at altitudes ranging from 140 to 5,888 feet (latitude 34 degrees N). Maximum density of colonies occurred at 4,000 feet. Five seedeating species were found in abundance, with separate but overlapping distribution ranges. *Veromessor pergandei* Mayr is found only at altitudes below 3,000 feet. It is replaced at that altitude by *Pogonomyrmex rugosus* Emery which in turn reaches peak abundance between 4,000 and 5,000 feet. Pogonomyrmex californicus Buckley can be found at most altitudes, but reaches a definite peak abundance at 5,000 feet. *Pheidole xerophila* Wheeler and *Pheidole gilvescens* Wheeler are abundant between 2,500 and 4,000 feet. The intraspecific spatial pattern of colony distribution was calculated for each species. The foraging method, foraging distance and diurnal activity of each species are highly adapted to the altitudinal range of the species. The distance from the nest that individuals of a colony travel in search of food was found to be a species-specific behavior, with low altitude species foraging the longest distances, high altitude the shortest. Species-specific temperature cues are used to initiate and terminate the daily foraging periods. They serve to allow each species to maximize its foraging time during the season when seeds are most abundant. The effect of the altitudinal gradient on species diversity of desert ants was measured. Diversity, as estimated by the number of species and by the diversity index (H) increases with altitude. Increases in diversity are related to an increase in length of the food production season with altitude. (Author) (FMM) *Keywords:* climate*, invertebrate*, ecology/ecosystem*, life history*

104 **BILLINGS, S.A., S.M. SCHAEFFER, and R.D. EVANS. 2000. Response of soil nitrogen dynamics to elevated CO_2 in a Mojave Desert ecosystem. In: Symposium Abstracts, The Ecological Society of America 85th Annual Meeting, August 6-10, 2000, Snowbird, UT.**

Growth and reproduction of many desert plant species are limited by the availability of water and plant-available nitrogen (N). It is theorized that atmospheric CO_2 may increase plant water-use efficiency, and thus increase net primary productivity (NPP) in deserts; however, we do not know how higher CO_2 levels will affect soil N availability. We are investigating the effects of elevated CO_2 (550 ppm) on soil N transformations at the Nevada Desert FACE (Free-Air Carbon Enrichment) facility in an intact Mojave Desert ecosystem. We examined soil N_2O and CO_2 fluxes, ammonia volatilization, and N-mineralization under three plant species and in plant interspaces, under both ambient and elevated CO_2. N_2O fluxes were undetectable in all seasons tested. Nitrogen mineralization was significantly higher under shrubs (27.9 ± 4.4 µg g_{soil}^{-1}), and lowest in plant interspaces (8.0 ± 2.8 µg g_{soil}^{-1}) where plant litterfall is minimal. Losses of N via NH_3 volatilization were appreciable (0.73 ± 0.12 vs. 0.65 ± 0.07 µg NH_3 -N m^{-2} d^{-1} with ambient and elevated CO_2, respectively). These data suggest a trend of lower losses under plant canopies than in interspaces, and lower losses with elevated CO_2. Soil CO_2 flux rates were significantly higher with elevated CO_2 (49.2 ± 12.5 vs. 17.6 ± 6.5 µg m^{-2} h^{-1}, $P < 0.05$); this data can serve as a proxy for underground microbial activity, especially in plant interspaces where roots are scarce. In conjunction with NH, losses and soil CO_2 data, this suggests microbial activity is highest where carbon supply is least limited. Our data indicate that soil microbial activity, and thus N-immobilization, may increase in an atmosphere of elevated CO_2. This change in N availability to plants may counteract any potential gains in NPP caused by increases in water-use efficiency. (Authors) *Keywords:* FACE*, perturbations*, soil property*, microbiota*, vegetation*

105 **BILLINGS, S.A., S.M. SCHAEFFER, T.N. CHARLET, S.F. ZITZER, S.D. SMITH, and R.D. EVANS. 2001. Response of soil nitrogen dynamics to elevated CO_2 in a Mojave Desert ecosystem. Ecological Society of America Annual Meeting, Snowbird, UT.**

Growth and reproduction of many desert plant species are limited by the availability of water and plant-available nitrogen (N). It is theorized that atmospheric CO_2 may increase plant water-use efficiency, and thus increase net primary productivity (NPP) in deserts; however, we do not know how higher CO_2 levels will affect soil N availability. We are investigating the effects of elevated CO_2 (550 ppm) on soil N transformations at the Nevada Desert FACE (Free-Air Carbon Enrichment) facility in an intact Mojave Desert ecosystem. We examined soil N_2O and CO_2 fluxes, ammonia volatilization, and N-mineralization under three plant species and in plant interspaces, under both ambient and elevated CO_2. N_2O fluxes were undetectable in all seasons tested. Nitrogen mineralization was significantly higher under shrubs (27.9 ± 4.4 µg g_{soil}^{-1}), and lowest in plant interspaces (8.0 ± 2.8 µg g_{soil}^{-1}), where plant litterfall is minimal. Losses of N via NH, volatilization were appreciable (0.73 ± 0.12 vs. 0.65 ± 0.07 µg NH_3-N m^{-2} d^{-1} with ambient and elevated CO_2, respectively). These data suggest a trend of lower losses under plant canopies than in interspaces, and lower losses with elevated CO_2. Soil CO_2 flux rates were significantly higher with elevated CO_2 (49.2 ± 12.5 vs. 17.6 ± 6.5 µg m^{-2} h^{-1}, $P < 0.05$); this data can serve as a proxy for underground microbial activity, especially in plant interspaces where roots are scarce. In conjunction with NH_3 losses and soil CO_2 data, this suggests microbial activity is highest where carbon supply is least limited. Our data indicate that soil microbial activity, and thus N-immobilization, may increase in an atmosphere of elevated CO_2. This change in N availability to plants may counteract any potential gains in NPP caused by increases in water-use efficiency. (Authors) *Keywords:* FACE*, perturbations*, soil property*, microbiota*, vegetation*

106 **BLACKBURN, W.H., and P.T. TUELLER. 1970. Pinyon and juniper invasion in black sagebrush communities in east-central Nevada. Ecology 51:841-848.**

As a means of studying inter- and intrazonal invasion in black sagebrush (*Artemisia nova* A. Nels) communities six maturity classes were established for pinyon (*Pinus monophylla* Torr. and Frem.) and juniper (*Juniperus osteosperma* ([Torr.]) Little) in east-central Nevada. Pinyon and juniper invade and increase in black sagebrush communities until the understory, except for a few hardy plants, is eliminated. Juniper invades first and tends to be eventually replaced by pinyon. Accelerated invasion by both species started about 1921 and is closely related to overgrazing, fire suppression, and climatic change. (Authors) *Keywords:* perturbations*, vegetation*, perennial plants*, ecology/ecosystem*

107 **BLANKENNAGEL, R.K., and J.E. WEIR, Jr. 1973. Geohydrology of the eastern part of Pahute Mesa, Nevada Test Site, Nye County, Nevada. Geological Survey Professional Paper 712-B, 35 pp.**

A deep structural depression, the Silent Canyon caldera, underlies the eastern part of Pahute Mesa, Nye County, Nev. The caldera is elliptical in plan and measures about 11 by 14 miles; the greater axis trends in a north-northeast direction. Exploratory drilling revealed a Tertiary volcanic section of ash-flow and ash-fall tuffs and rhyolitic lava flows which attained thicknesses in excess of 13,686 ft. Hydraulic tests made in deep drill holes indicated that these volcanic rocks are capable of transmitting water and that measurable permeability occurs at depths greater than 3,500 ft below the top of the saturated zone. Most movement of ground water beneath the mesa occurs through interconnecting fault and joint systems. Fractures are more common in rhyolitic lava flows and in densely welded ashflow tuffs, and these fractures have a greater tendency to remain open than do those in ash-fall and nonwelded ash-flow tuffs. The yield of water to wells from intervals of ash-fall and nonwelded ash-flow tuffs, particularly those that are zeolitized or argillized, is low. Hence, these rocks are considered the best media for mining of underground chambers in the saturated zone. In the Silent Canyon caldera, depth to water ranges from about 1,952 ft (alt 4,164 ft) in the western part to 2,350 ft (alt 4,685 ft) in the eastern part. In the extreme northwestern part of the Nevada Test Site, outside the caldera, the depth to water is about 850 ft (alt 4,700 ft). Stable and declining head potentials occur with depth in all but one of the holes drilled in the eastern part of the report area; variable heads in the upper 1,500 ft of the saturated zone and then increasing heads to total drilled depth occur in holes drilled in the western part. Pumping tests indicate that transmissivities range from 1,400 to 140,000 gal per day per foot. The greatest transmissivities occur in holes drilled along the east margin of the caldera, where the principal rock type in the saturated zone is rhyolite. Water derived from drill holes at Pahute Mesa is sodium potassium type. These chemical constituents comprised over 90 percent of the total cations in more than half the samples that were analyzed. Ground water beneath Pahute Mesa moves southwestward and southward toward the Amargosa Desert through Oasis Valley, Crater Flat, and western Jackass Flats. The flow, across a 15-mile underflow strip which extends from the hydraulic barrier on the west to the ground-water divide on the east, is estimated to be 8,000 acre-feet per year. Owing to the difficulty in obtaining accurate porosity data, estimates of groundwater velocity vary as much as two orders of magnitude -- 5 to 250 ft per year. Based on the assumption that most ground-water movement occurs along interconnected fractures and that some movement occurs through interstices, a reasonable estimate of velocity is less than 15 ft per year. (Authors) *Keywords:* geology*, hydrology*

108 BLISS, W., and L. DUNN. 1971. Measurement of plutonium in soil around the Nevada Test Site. In: (Fowler, E.B., R.W. Henderson, and M.F. Milligan, Co Chrs.) Proceedings of the Environmental Plutonium Symposium at Los Alamos, NM, 1971 (LA-4756), pp. 89-92.

Experiments conducted at the AEC's Nevada Test Site between 1951 and 1963, using plutonium in both critical and sub-critical configurations, resulted in distribution of plutonium beyond the boundaries of the Test Site. The Southwestern Radiological Health Laboratory of the Environmental Protection Agency is conducting a survey to assess the distribution and concentration of plutonium in the off-site environment. Special sampling methods were devised since desert soil is too coarse and dry for auger and cookie cutter sampling techniques. Soil sample analyses are performed by a dissolution, ion exchange, and electrodeposition procedure followed by alpha spectroscopy. Plutonium was detected in four locations around the Nevada Test Site. These locations correspond to fallout areas previously identified for the various test series. Plutonium concentrations in the top 3 cm of soil were 10 to 100 times greater than the concentration in soils from areas not subject to contamination by these series. (Authors) *Keywords:* EPA*, radionuclide inventory*, methods*

109 BLOMQUIST, K.W., and G.E. LYON. 1995. Effects of Soil Quality and Depth on Seed Germination and Seedling Survival at the Nevada Test Site. In: Proceedings of the Wildland Shrub and Arid Land Restoration Symposium Las Vegas, NV, October 19-21, 1993. Roundy, B.A., E.D. McArthur, J.S. Haley, and D.K. Mann (Compilers). Gen. Tech. Rep. INT-GTR-315. U.S. Department of Agriculture, Forest Service; Intermountain Research Station, Ogden, UT, pp. 57-62.

A study was developed to test the effects of soil quality and depth on seedling emergence and survival. Fifty-six plots were established and two treatments were tested. The first treatment compared native topsoil to subsoil imported from a borrow pit. The second treatment compared four different depth ranges of both soil types. All plots received identical seeding treatments. Seedling density was measured after emergence. Overall seedling densities averaged 10.3 ± 8.8 (SD) plants/m^2. Statistical analysis revealed a significant interaction between the two treatment factors. The subsoil had increasing densities from the deep soil depths to the shallow depths while the topsoil had increasing densities from the shallow soil depths to the deep depths. (Authors) *Keywords:* YMSCO*, soil property*, perennial plants*, life history*, revegetation*

110 **BLOMQUIST, K.W., T.A. LINDEMANN, G.E. LYON, D.C. STEEN, C.A. WILLS, S.A. FLICK, and W.K. OSTLER. 1995. Current Distribution, Habitat, and Status of Category 2 Candidate Plant Species on and Near the U.S. Department of Energy's Nevada Test Site. Report No. 11265-1149, UC-708. EG&G Energy Measurements, Las Vegas, NV, 101 pp.**

Results of surveys conducted between 1991 and 1995 were used to document the distribution and habitat of 11 Category 2 candidate plant species known to occur on or near the Nevada Test Site (NTS). Approximately 200 areas encompassing about 13,000 ha were surveyed. Distributions of all species except *Frasera pahutensis* and *Phacelia parishii* were increased, and the ranges of *Camissonia megalantha, Galium hilendiae* ssp. *kingstonense, Penstemon albomarginatus,* and *Penstemon pahutensis* were expanded. The status of each species was assessed based on current distribution, population trends, and potential threats. Recommendations were made to reclassify the following five species to Category 3C: *Arctomecon merriamii, F. pahutensis*, *P. pahutensis*, *Phacelia beatleyae,* and *Phacelia parishii.* Two species, *C. megalantha* and *Cymopterus ripleyi* var. *saniculoides*, were recommended for reclassification to Category 3B status. No recommendation was made to reclassify *Astragalus funereus, G. hilendiae* ssp. *kingstonense*, *P. albomarginatus,* or *Penstemon fruticiformis* var. *amargosae* from their current Category 2 status. Populations of these four species are not threatened on NTS, but the NTS populations represent only a small portion of each species' range and the potential threats of mining or grazing activities off NTS on these species was not assessed. Conservation measures recommended included the development of an NTS ecosystem conservation plan, continued conduct of preactivity and plant surveys on NTS, and protection of plant type localities on NTS. (Authors) *Keywords:* management*, sensitive plants*, ecology/ecosystem*, taxonomy*

111 **BLOMQUIST, K.W., C.A. WILLS, W.K. OSTLER, K.R. RAUTENSTRAUCH, and T.P. O'FARRELL. 1992. Distribution, Life History, Management, and Current Status of *Astragalus beatleyae* on the U.S. Department of Energy's Nevada Test Site. Report No. 10617-2187, EG&G Energy Measurements, Santa Barbara Operations, Goleta, CA, pp. 41.**

This report presents the results of an *Astragalus beatleyae* monitoring study conducted on the Nevada Test Site (NTS) from 1989-1991 and the distribution and current status of *A. beatleyae* based on the finding of this study and observations from past field surveys. The geographic range of *A. Beatleyae* has continued to increase since 1968 when the species was first discovered. Initially, *A. beatleyae* was considered endemic to Pahute Mesa on the NTS. However, it is now known to occur in isolated populations over a range of 309 km^2 extending off Pahute Mesa onto Nellis Air Force Range. A map showing the locations of all known *A. beatleyae* populations is presented. Thirteen *A. beatleyae* populations located on the NTS were studied to assess the species' habitat characteristics, life history, reproductive success. And population density. *A. beatleyae* habitat is typically characterized by shallow gravelly soil derived from volcanic tuff. The majority of known populations occur within the pinyon-juniper-sage vegetation association at elevations of 1,850-2,275 m. A few populations have been found recently at lower elevations in the transition zone between the Mojave and Great Basin deserts. Over 5,000 individual plants were monitored during 1990 and 1991 to document survival, phenological condition, growth, and reproduction. *A. beatleyae* is basically an annual or short-lived perennial with only 46 of the 5,000 plants monitored showing reproductive activity for two or more years. Reproduction is primarily by seeds which generally germinate in the spring (March-May). Density averages for all study location combined were 7.8, 14.4, and 26.7 plants/100m^2 during 1989, 1990, and 1991, respectively. This overall increase was not consistent among populations. Some populations showed declines in density during the study period. Density fluctuations do not appear to be related to NTS activities. Conclusions about the future status need to protect *A. beatleyae* are presented. (Authors) *Keywords:* management*, sensitive plants*, ecology/ecosystem*, life history*

112 **BOONE, J.L. 1997. Assessing Gender in Free-Ranging Desert Tortoises (*Gopherus agassizii*) using External Morphology. In: The Desert Tortoise Council Proceedings of 1997-1998 Symposia, p. 64. Desert Tortoise Council, Inc., Wrightwood, CA.**

When using external morphology to determine the gender of tortoises, researchers have long relied on the work of Woodbury and Hardy (1948; Ecological Monographs, 18:145-200). However, these results pertain primarily to large tortoises, and there has always been a need for a quantitative method to determine gender of smaller tortoises. We applied multivariate statistical techniques to 22 measurements of the external morphology of 105 tortoises to determine whether these measurements could be used to identify male and female tortoises. We determined gender independently of external morphology (serum testosterone levels, x-rays, behavior) for 35 females and 13 males. Of the remaining individuals, those with carapace length (CL) greater than 200 mm (5 females, 33 males) were assigned to a gender category based on morphology that was similar to individuals of known gender. Nineteen individuals (CL < 200 mm) of unknown gender were not assigned to gender *a priori*. Three discriminant analyses were performed: only animals of known gender, all larger animals (CL > 192), and all smaller animals (CL < 220). Analysis of the data set containing only animals of known gender correctly classified all but two males (CL = 179, 206) using 11 characters. In the trivial case of discriminating larger animals, all classified correctly. Although it is generally considered easy to classify larger animals based on external morphology, the model required 9 characters to correctly classify all of these individuals. When only smaller animals were considered, all individuals of known gender classified correctly using 5 characters, and when the 19 small individuals of unknown gender were classified with this discriminant function, all animals fell cleanly into two groups. Only three characters were important for separating males and females in all analyzes. In each, a deep plastron concavity (always the largest coefficient) and wide front foot (always a large coefficient) were associated with males. Gular length projection was only associated with males for the data sets containing all animals and large animals. For the smaller tortoises, a long gular was associated with females. Despite the apparent success of these models, when the discriminant scores were plotted against carapace length (a proxy for age), it became clear that males with a CL of 100-190 were probably classified correctly, but all animals smaller than this were classified as females. While it is possible that all of these animals were female, it is more likely that animals with a CL less than 100 included males that had not started to acquire secondary sexual characters. Therefore, it appears possible to use multivariate statistics to determine the gender of tortoises with carapace lengths as short as about 100 mm. (Author) *Keywords:* YMSCO*, desert tortoise*, methods*

113 BOONE, J.L., and P.E. LEDERLE. 1998. The Birds of Yucca Mountain, Nevada, and Vicinity. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00092 Rev 00. Las Vegas, NV, 10 pp.

Potential direct and indirect environmental impacts of the U.S. Department of Energy's Yucca Mountain Site Characterization Project were monitored during 1989-1998. While engaged in monitoring activities, project biologists kept records of the birds they saw in the Yucca Mountain area. These records, plus historical bird observations, were compiled to create a checklist of the birds for Yucca Mountain. A total of 120 species were observed, most of which were transient or occasional visitors (e.g., neotropical warblers, shorebirds). Twenty-two species of birds regularly nest, or probably nest, in the area. An additional 20 species occasionally may nest at Yucca Mountain. Abundance records were not kept, but the most common residents were probably Black-throated Sparrows, Mourning Doves, and House Finches. Twelve species were added to the list of birds reported from the Nevada Test Site. No Federally-listed threatened or endangered species of birds were observed at Yucca Mountain. Peregrine Falcons (endangered) and Bald Eagles (threatened) have been observed on the Nevada Test Site, but they only migrate through the area. Between 1989 and 1998, no sightings of these two species were reported at Yucca Mountain. Golden Eagles (protected under the Bald and Golden Eagle Protection Act) were commonly seen in the Yucca Mountain area. The Mountain Plover, a candidate for listing under the Endangered Species Act, is an uncommon transient in the region that has not been reported at Yucca Mountain. Several species classified as protected or sensitive by other governmental organizations (U.S. Bureau of Land Management: Ferruginous Hawk, Burrowing Owl; State of Nevada: game species) occur in the region. (Authors) *Keywords:* YMSCO*, sensitive animals*, bird*, ecology/ecosystem*

114 BOONE, J.L., and K.R. RAUTENSTRAUCH. 1998. Survival of Desert Tortoises at Yucca Mountain, Nevada, 1989-1995. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00086 Rev 00. Las Vegas, NV, 16 pp.

Potential impacts of the U.S. Department of Energy Yucca Mountain Site Characterization Project on desert tortoises were monitored during 1989-1995. As part of this effort, annual survival rates were estimated for radiomarked tortoises. In general, survival rates were low for hatchlings and juveniles (approximately 50% survival per year), moderate for immature and subadults (approximately 85%), and high for adults (approximately 99%) during this study. This pattern of survival is typical for reptiles and implies that few young animals survive to adulthood, but that if adulthood is reached, they tend to live for a relatively long time. Of 276 tortoises monitored, 52 died. Of those that died, 17 likely died as the result of predation by large mammals or birds, 31 died from causes other than predation, and 4 died of unknown causes. Three of 52 deaths (6%) occurred as a result of being hit by vehicles on roads, but all other deaths (94%) appeared to be natural. Most of the animals that died during the study were hatchlings and juveniles; only three adults died. (Authors) *Keywords:* YMSCO*, desert tortoise*, life history*

115 **BOONE, J.L., and C.L. SOWELL. 1999. *Eumeces gilberti rubricaudatus* (Western Redtail Skink). Herpetological Review 30(1):52.**

A specimen was collected in Midway Valley on the east flank of Yucca Mountain, Nevada Test Site, Nye Co., Nevada, ca. 1,130 m elev., on 24 May 1995. Specimen was collected in creosotebush (*Larrea tridentata*) bajada habitat which was drier and lower in elevation than would be expected for the species in this region. This was the only *E. gilberti* captured in this area during 6,336 trap-days (24 h/d) of pitfall and funnel trapping and ca. 1,000 person-days (4 h/d) of noosing conducted from 1991 to 1995. (Authors) *Keywords:* YMSCO*, reptile*, taxonomy*

116 **BOONE, J.L., D.L. RAKESTRAW, and K.R. RAUTENSTRAUCH. 1999. *Gopherus agassizii* (Desert Tortoise): Predation. Herpetological Review 30(1):40.**

Here, we report an observation of a hatchling tortoise, fitted with a radiotransmitter, that was preyed upon by native fire ants (*Solenopsis* sp.) in the eastern Mojave Desert at Yucca Mountain, Nevada. (Authors) *Keywords:* YMSCO*, desert tortoise*, invertebrate*, nutrition/diet*, ecology/ecosystem*

117 **BOONE, J.L., C.L. SOWELL, and R.A. GREEN. 1998. Indirect Impacts of Site Characterization Activities on the Abundance of Side-blotched Lizards (Uta stansburiana) at Yucca Mountain, Nevada: 1993 to 1995. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00036 Rev 00. Las Vegas, NV, 14 pp.**

Potential impacts of the U.S. Department of Energy Yucca Mountain Site Characterization Project on animals were monitored during 1989-1997. As part of this effort, biologists studied lizards and snakes during 1991-1995 using capture-mark-release-recapture techniques on a number of treatment and control plots. Twenty-seven species were recorded, but only side-blotched lizards were sufficiently abundant to statistically analyze the potential effects of site characterization activities on the abundance of lizards. For this report, analysis was limited to data on the abundance of side-blotched lizards collected during 1993-1995. As might be expected in a harsh and unpredictable desert environment, the number of lizards changed from one sampling session to the next. Overall, the number of lizards declined throughout 1993-1995. The number of lizards on treatment and control plots declined equally and in synchrony. No evidence was found to suggest that construction activities associated with Site Characterization indirectly affected the abundance of side-blotched lizards. (Authors) *Keywords:* YMSCO*, perturbations*, reptile*, ecology/ecosystem*

118 **BOONE, J.L., C.L. SOWELL, and R.A. GREEN. 1998. Indirect Impacts of Site Characterization Activities on Small Mammals at Yucca Mountain, Nevada. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00046 Rev 00. Las Vegas, NV, 20 pp.**

From 1989 to 1995, small mammal populations in the vicinity of Yucca Mountain were examined for evidence of indirect impacts due to site characterization activities. The presence of indirect impacts were evaluated by comparing the number of animals on control plots with those on treatment plots before and after November 1992, the date of grading the Exploratory Studies Facility (North Portal) site. Animal abundance fluctuated over the years, but the numbers generally fluctuated in synchrony, and differences in the population sizes on the control and treatment plots were generally small. Two species, little pocket mice and canyon mice, showed no impact-related changes in population size. However, changes in the population sizes of longtailed pocket mice and Merriam's kangaroo rats showed patterns of change that were consistent with those expected from impacts of site characterization activities. However, these patterns were probably due to natural factors such as carrying capacity; habitat differences between plots; and demographic stochasticity in survival, reproduction, and sex ratios in small populations rather than human impacts. No species became extinct, nor were any introduced species detected on any study plot. These data support the hypothesis that populations of small mammals fluctuate naturally at Yucca Mountain, and that there have been no biologically significant impacts on rodent populations resulting from the Yucca Mountain Site Characterization Project. (Authors) *Keywords:* YMSCO*, perturbations*, mammal*, ecology/ecosystem*

119 **BOONE, J.L., C.L. SOWELL, M.K. COX, and R.A. GREEN. 1998. Species Composition and Abundance of Reptile Populations in Selected Habitats at Yucca Mountain, Nevada, with Annotated Checklist. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00038 Rev 00. Las Vegas, NV, 35 pp.**

From 1991 to 1995, a total of 3,405 reptiles were captured in the three major low-elevation habitat types throughout the Yucca Mountain area, providing data on the presence, habitat preference, and habitat specific population densities of 27 species of reptiles (12 lizard, 14 snake, and 1 tortoise species). Sideblotched lizards and western whiptail lizards were the most abundant lizards; coachwhip snakes and long-nosed snakes were the most abundant snakes. Only side-blotched lizards and desert tortoises were captured in all habitat types. Of the 27 species detected, 20 were captured in Creosotebush-Wolfberry- Hopsage habitat near the Exploratory Studies Facility, 16 were captured in the sandy Creosotebush- Bursage habitats in Jackass Flats, and 15 were captured in the lower-elevation Blackbrush habitat east of the Exploratory Studies Facility. The chuckwalla, formerly a federally listed Category II species, was locally common and widely distributed throughout the area in rocky habitats. Also widely distributed throughout the area was the desert tortoise, the only reptile that was federally listed as threatened or endangered. Demographic and natural history notes for all species found at Yucca Mountain are discussed in Appendix C. (Authors) *Keywords:* YMSCO*, desert tortoise*, sensitive animals*, reptile*, ecology/ecosystem*, life history*

120 **BOSTICK, K.V., L.J. LANE, and T.E. HAKONSON. 1987. Preliminary Results of Erosion and Contamination Transport Research on the Nevada Test Site. In: The Dynamics of Transuranics and Other Radionuclides in Natural Environments (Howard, W.A., and R.G. Fuller, Eds). U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV. NVO-272, pp. 517-525.**

A cooperative research program on the Nevada Test Site involving application of rainfall simulators on runoff-erosion plots is described and discussed relative to parameter estimation for hydrologic models. Preliminary results from experiments conducted in 1983 are used to illustrate the influence of vegetation and erosion (or desert) pavement (a natural gravel mulch) on runoff and erosion. Preliminary results from the plots demonstrate that the magnitude of runoff and erosion is greatly influenced by the erosion pavement and moderately influenced by the plant cover. (Authors) *Keywords:* NAEG*, hydrology*, vegetation*, ecology/ecosystem*, methods*

121 **BRADLEY, W.G., and J.E. DEACON. 1965. The biotic communities of southern Nevada. University Nevada, Desert Research Inst. Preprint Series 9, 86 pp.**

Describes the biota of the Mohave Desert found in southern Nevada exclusive of the southern portion of the Nevada Test Site. A total of 13 terrestrial and hydric communities are described showing the affinities of 887 species of vascular flora, 37 fish, 121 species of amphibians, reptiles and mammals, and approximately 290 species of birds. (TPO) *Keywords:* wetlands*, vegetation*, fish*, amphibian*, bird*, reptile*, mammal*, ecology/ecosystem*, taxonomy*

122 **BRADLEY, W.G., and K.S. MOOR. 1975. Ecological Studies of Small Vertebrates in Pu-Contaminated Study Areas of NTS and TTR. In: *The Radioecology of Plutonium and Other Transuranics in Desert Environments*. White, M.G., and P.B. Dunaway (Eds.). NVO-153, U.S. Energy Research & Development Administration, Nevada Operations Office, Las Vegas, NV, pp. 151-185.**

Ecological studies of vertebrates in plutonium-contaminated areas of the Nevada Test Site (NTS) were initiated in March, 1972, and have continued to date. In September, 1973, standard census methods were also employed to derive a qualitative and quantitative inventory of vertebrate biota of four Nevada Applied Ecology Group (NAEG) study areas of the Tonopah Test Range (TTR). A checklist of vertebrates of NAEG study areas of NTS and TTR is presented. Data are presented on vertebrate composition, relative abundance, and seasonal status in the study areas. More detailed data on rodent populations are included for Clean Slate 2 and Double Track, TTR, and Areas 11 and 13, NTS. Four species of lizards are found in TTR study areas. Two species of insectivorous lizards are common in all TTR study areas (*Phrynosoma platyrhinos* and *Uta stansburiana*). In addition, the carnivorous lizard, *Crotophytus wislizeni*, occurs commonly in all NAEG study areas of NTS and TTR. A complete quantitative and qualitative census of bird populations was not possible during the report period. The horned lark is the only common-to-abundant resident in NAEG study areas. The more northern areas of NTS and TTR appear to have a rich raptor fauna which may be utilized for additional study in the future. There are two common rodents in study areas of TTR and both are granivores. In addition, two species characteristic of the Great Basin Desert were found in Clean Slate 2: *Microdipodops megacephalus*, found also in Area 13, NTS, and Double Track, TTR, and *Spermophilus townsendii*. An additional rodent, *Peromyscus maniculatus,* was found in NTS study areas for the first time in the spring of 1974, probably the result of the unusually wet year of 1973-1974. Concentrations of ^{239}Pu and ^{241}AM were determined in pelt or skin, GI tract, and carcass of 13 lizards and 16 mammals resident on Clean Slate 2, TTR, and Area 11, NTS. A total of 71 animals were collected for radioanalysis. However, the data were not available at the time this report was written. Pu tissue burdens were highest in lizards from Area 11 GZ. Maximum values obtained in nCi/g ash were 30.9, 42.2 and 0.43 for the pelt, GI tract, and carcass, respectively. Maximum ^{239}Pu values in tissues of small rodents from Area 11 (not from GZ) were 11.4, 6.49, and 0.20 nCi/g ash for pelt, GI tract, and carcass, respectively. Pu/Am ratios were relatively consistent in tissue samples of lizards and small mammals from Area 11 (approximately 6:1, Pu/Am). Pu/Am ratios were not consistent in vertebrates of Clean Slate 2, TTR, and appeared to be lower in carcass (28:1, Pu/Am in mammals) than GI tract (9:1, Pu/Am in mammals). Although this trend was more conspicuous in mammals, it was also evident in reptiles. Average discrimination factor of ^{239}PU in GI tract and carcass of small vertebrates was in the order of magnitude of 10^{-2} in most instances Although sample numbers were small (N = 4), reptiles from Clean Slate 2 exhibited an extremely low discrimination rate (5.2×10^{0}). (Authors) *Keywords:* NAEG*, bird*, mammal*, reptile*, ecology/ecosystem*, radiation*

123 **BRADLEY, W.G., and K.S. MOOR. 1976. Ecological Studies of Small Vertebrates in Pu-Contaminated Study Areas of Nevada Test Site and Tonopah Test Range. In: *Studies of Environmental Plutonium and Other Transuranics in Desert Ecosystems.* White, M.G., and P.B. Dunaway (Eds.). NVO-159, U.S. Energy Research & Development Administration, Nevada Operations Office, Las Vegas, NV, pp. 53-65.**

Various standard census methods were employed during the period March, 1972-May, 1975, to obtain a qualitative and quantitative inventory of the vertebrate biota in seven Nevada Applied Ecology Group (NAEG) intensive study areas of the Nevada Test Site (NTS) and Tonopah Test Range (TTR). In general, vertebrate populations in NAEG study areas correspond with earlier investigations of populations in uncontaminated study areas. Animals known to be residents in the study areas for at least three months were sacrificed and autopsied. Tissue samples for radioanalysis included pelt or skin, GI tract, and carcass. Over 300 tissue samples have been collected and shipped to laboratories for ^{239}Pu and ^{241}Am determinations. However, many of these data are forthcoming. Examination and discussion of many aspects of Pu and Am uptake await completion and receipt of laboratory analyses. Data are presented on Pu and Am tissue burdens in *Dipodomys microps*, a granivorous rodent, from three study areas of NTS and TTR. Ratios of Pu/Am were significantly lower in the carcass than in the pelt or GI tract in this rodent, whereas ratios in tissue of lizards were uniform. A general trend of preferential Am uptake is suggested in certain rodents. It is suggested that the food habits and burrowing behavior of these rodents may be contributing factors to this apparent trend. Some baseline hematological data obtained from 50 rodents collected from uncontaminated control areas off-site are presented. These data will be used as a basis for comparison with blood values obtained from resident animals of NAEG intensive study areas. Possible future plans are discussed, such as reducing the number of continuous study areas, and intensifying the investigation of certain areas to include preliminary observations on the availability of Pu and Am in rodent burrows. (Authors) *Keywords:* NAEG*, mammal*, reptile*, ecology/ecosystem*, radiation*, physiology*

124 **BRADLEY, W.G., and K.S. MOOR. 1978. Ecological Studies of Small Mammals in a Nuclear Site on Nevada Test Site. In: *Selected Environmental Plutonium Research Reports of the NAEG.* White, M.G., and P.B. Dunaway (Eds.). NVO-192, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 1-13.**

Ecological studies of small vertebrates in nuclear event sites in NTS began in spring 1977 with the establishment of a permanent live-trapping grid in Little Feller II. These study areas are located in Area 18, a relatively homogeneous area vegetatively and topographically. Most of the flora and fauna are typical of the Great Basin desert found in southern Nevada. Dominant vegetation includes *Artemisia spp*. and to a lesser extent *Atriplex*. *Salsola* is an abundant weed in areas that have been mechanically disturbed such as the vicinity of GZ. A 400-station live-trapping grid was established in Little Feller II, April 1977. Sixteen lines of live traps (25 traps per line, each trap 50 feet apart) comprise the 8.4 hectare grid encompassing GZ. Nine trapping periods have been completed to date totaling over 10,000 trap nights. Over 400 small vertebrates have been marked for permanent identification in the grid. Over 60 known residents (animals marked 3 months previously and recaptured in the same vicinity) have been collected and prepared for shipping; however, radioanalytical results were not available to include in this report. Both census and field note observations were used to develop an inventory of the vertebrates found in the study areas. Sufficient data have been generated from Little Feller II to estimate density of rodents. These data and comparative data from Area 5 (Mohave Desert), Area 11 (Transition), and Area 13 (Great Basin) are presented. It was readily apparent that rodents in general were more numerous in Little Feller II. In addition, *Dipodomys ordii*, a Great Basin species, was an important new addition to the rodent fauna. It is believed that with the increased numbers of rodents found in this study area, a good sample of rodents from each activity strata can be obtained. (Authors) *Keywords:* NAEG*, invasive species*, annual plants*, perennial plants*, mammal*, ecology/ecosystem*, radiation*

125 BRADLEY, W.G., K.S. MOOR, and S.R. NAEGLE. 1977. Plutonium and Other Transuranics in Small Vertebrates: A Review. In: *Transuranics in Natural Environments*. White, M.G., and P.B. Dunaway (Eds.). NVO-178, Nevada Applied Ecology Group, U.S. Energy Research & Development Administration, Las Vegas, NV, pp. 385-405.

The published data relevant to transuranics in small vertebrates inhabiting terrestrial environments is reviewed. Experimental results indicate that atomic size and valence state affect rates of absorption, transportation, and excretion of transuranics in living systems. Whereas there is a marked tendency for transuranics to hydrolyze to insoluble colloidal products at physiological pH, complexing agents and chelation enhance solubility and transportability. The natural modes of uptake of transuranics by vertebrates include absorption from the gut, the intact or damaged skin, and inhalation. Absorption from the gut into the bloodstream is very low. Potential hazards may exist if complexing or chelating agents are present, if absorption is continuous, or if exposure involves young animals. The intact skin provides an effective barrier to absorption of transuranics. Relatively high levels of absorption may occur when transuranics are administered subcutaneously or intramuscularly, particularly with increased acidity and solubility of the compounds. Inhalation is probably the most hazardous natural route of uptake. Insoluble transuranic compounds are retained in the lung and soluble compounds are transported rapidly via the blood to bone, liver, and other organs. Deposition of plutonium in mammalian gonads resulting in a decrease in spermatogenesis, ovarian damage, and reduced fecundity is documented. The current knowledge of the behavior of transuranics in terrestrial environments is limited. Plutonium and americium uptake by small mammals has been documented. High variability in animal tissues makes analysis difficult. In addition, there is evidence that uptake may be species related. Whereas resuspension of sedimentation (inhalation) may be the most important route of uptake, high levels of plutonium and americium in the gut of small mammals indicate that chronic ingestion may be an important hazard. Plutonium body burdens were related to depressed leukocyte count on a statistical basis. Reduced rodent populations in areas of high plutonium concentrations illustrate the problems of evaluating uptake by mobile animals. (Authors) *Keywords*: NAEG*, vertebrate*, mammal*, physiology*, radiation*

126 BRADLEY, W.G., K.S. MOOR, and S.R. NAEGLE. 1977. Plutonium Concentrations and Pu/Am Ratios In Small Vertebrates From NAEG Intensive Study Areas of NTS. In: *Transuranics in Desert Ecosystems*. White, M.G., and P.B. Dunaway (Eds.). NVO-181, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 207-219.

Radioecological studies of small vertebrates in Pu-contaminated areas of NTS began in spring 1972 and have continued to date. Species composition, relative abundance, and other pertinent ecological data have been presented in previous reports. In addition, data analysis of Pu and Am concentrations in selected rodent and lizard species has been presented for all NAEG Intensive Study Areas. This report provides further analysis of Pu concentrations in small vertebrates of Areas 5 and 11, NTS. Data are most adequate for analysis of Pu concentrations in *Perognathus longimembris* which are grouped by activity strata from Areas 5 and 11. Whereas there is extreme variability in Pu concentrations within the three tissue components collected from the same strata, tissue burdens are proportional to soil Pu concentrations and are lower by 2 to 3 orders of magnitude. In order to provide adequate sample sizes for analysis, *Dipodomys merriami* and *D. microps* were pooled from the two study areas. Similarly, tissue burdens were highly variable and proportional to soil Pu concentrations but exhibited somewhat lower concentrations than those found in *P. longimembris*. Five species of insectivorous lizards were pooled from the two study areas. Tissue burdens exhibited somewhat less variability than rodents and were proportional to soil Pu concentrations. Small vertebrates from Area 11, NTS, were analyzed by trophic category. No significant differences were detected in Pu concentrations or Pu/Am ratios in the tissues of the three trophic categories. Ratios of Pu/Am in the GI tract exhibited consistency and lower variability than for pelt or carcass in all trophic categories from both strata. (Authors) *Keywords:* NAEG*, mammal*, reptile*, radiation*

127 BRADY, D.N. (Compiler). 1972. Environmental surveillance sampling results at the Nevada Test Site, July 1969 through June 1970. NVO-410-11, 58 pp.

Data derived from the environmental surveillance program at the Nevada Test Site (NTS) for fiscal year 1970 are presented. Gross beta radioactivity results for water and air samples collected throughout the NTS are listed and measurements of gamma radioactivity in soil and vegetation samples are also documented. Tabular data is supplemented by graphical presentations and sampling locations are shown in maps depicting the NTS. (Author) *Keywords:* radionuclide inventory*, vegetation*, radiation*

128 **BRANDENBURG, M.K., H.L. MILLS, W.H. RICKARD, and L.M. SHIELDS. 1962. Effects of acute gamma radiation on growth and morphology in *Pinus monophylla* Torr. and Frem. (pinyon pine). Radiation Botany 2:251-263.**

A *Pinus monophylla* (pinyon pine) tree was irradiated from a position near the base for eight hours with a Multitron cobalt-60 unit in April 1960. Shoot apices within fifteen inches (0.38 m, ca. 1,300 r to 8,000 r) showed almost immediate growth inhibition and were killed within four months. Between two and three feet from the source (0.61 to 0.92 m, ca. 500 r to 200 r) the terminal buds elongated, but by the end of the season had died, and one or two basal lateral buds had developed per shoot. At three to three and one-half feet (0.92 to 1.07 m, ca. 200 r to 150 r) stem elongation proceeded, but the 1961 bud primordia were dwarfed, and lateral buds elongated. Out to four feet (1.22 m, ca. 100 r) no needles developed on the 1960 stem length. From four to five feet from the source (1.22 to 1.53 m, ca. 100 r to 80 r) the number of needles was reduced to from one-half to one-third normal, and approximately one-half were dwarfed. Gnarled growth was common in these dwarf needles. Two vascular tissue anomalies occurred in a number of grossly abnormal as well as in normal appearing needles collected four to six feet from the source (1.2 to 1.8 m; dosages ca. 100 r to below 50 r). One, the double vascular strand probably is related to the naturally occurring fusion process. The other anomaly involved reduction of or lack of vascular tissue. Xylem radii measurements in transverse sections of young stems indicated a decrease in growth for 1960, ranging from 3 to 8 percent, correlated with increasing exposure. Stem tip elongation in the experimental tree compared with that of the controls was inhibited at doses as low as 15 r. Lateral branching assumes a significant role in shoot recovery from radiation damage, particularly at exposures great enough to affect the actively growing regions of the stem but not the other functional portions. (Authors) *Keywords:* perennial plants*, physiology*, radiation*

129 **BRENNAN, J.M. 1965. Five new chiggers from southwestern United States (Acarina: Trombiculidae). Journal of Parasitology 51:108-113.**

Described and figured are *Euschoengastoides sloomi* off *Neotoma lepida*, Nevada; *Pseudoschoengastia aeci* off *Neotoma lepida*, Nevada; *Trombicula sprocssi* off *Pipistrellus hesperus*, Arizona; *Trombicula univari* off *Pipistrellus hesperus*, Arizona; and *Trombicula veanda* off *Neotoma lepida*, Nevada. Other host and locality records from Arizona and California are included. (Author) *Keywords:* invertebrate*, taxonomy*

130 **BRINTON, E.P., D.E. BECK, and D.M. ALLRED. 1965. Identification of the adults, nymphs and larvae of ticks of the genus *Dermacentor* Koch (Ixodidae) in the western United States. Brigham Young University Science Bulletin, Biological Series 5(4), 44 pp.**

Contains illustrated keys to assist in the specific identification of the larval, nymphal, and adult stages of ticks belonging to the genus *Dermacentor* in the western United States including the Nevada Test Site. Information includes external anatomy and morphology, as well as geographic and ecological distributions, seasonal occurrence, and host relationships. (TPO) *Keywords:* invertebrate*, ecology/ecosystem*, taxonomy*

131 **BROWN, K.W., and B.J. MASON. 1968. Range survey, Area 18, Nevada Test Site. SWRHL-52, 42 pp.**

The ocular reconnaissance method of surveying vegetation was used to survey 13,630 acres in Area 18, Nevada Test Site. A total of 233 line transects were established to obtain species distribution, composition and ground cover. There were six distinct plant communities identified: two sagebrush (*Artemisia arbuscula* subsp. *nova, A. tridentata*), two annual (*Salsola kali* var. *tenuifolia, Eriogonum*), one grass, and one Desert Shrub. These six communities contained a total of 36 families and 85 species. The *A. arbuscula* subsp. *nova* community occupied the largest area, 6,337 acres, and the *Eriogonum* sp. community the smallest, 17 acres. (Authors) *Keywords:* EPA*, invasive species*, vegetation*, annual plants*, perennial plants*, ecology/ecosystem*

132 **BROWN, K.W., and J.C. McFARLANE. 1973. Deposition and retention of ^{131}I on *Grayia spinosa* following Baneberry. Health Physics 24: 680-681.**

A study is reported of the measurement of the deposition of radioactive fallout (^{131}I), following the underground nuclear weapons test Baneberry, on dormant rangeland vegetation 2 miles from the emplacement hole. By comparing the activity on samples of *Grayia spinosa* to that on planchets placed in the center of the stand of plants it was found that the effective collection surface of these plants is 235 cm^2/g. It is stated that the importance of this work lies in the development of the concept that in the absence of man-made collection systems, plants (even dormant) can provide information about release of fallout materials. (UK) *Keywords:* radionuclide inventory*, perennial plants*, radiation*

133 BROWN, G.A., and K.R. RAUTENSTRAUCH. 1995. Burrow Use by Desert Tortoises at Yucca Mountain, Nevada. In: The Desert Tortoise Council Proceedings of 1995 Symposium, pp. 72. Desert Tortoise Council, Inc., San Bernadino, CA.

We evaluated burrow use by desert tortoises (*Gopherus agassizii*) at Yucca Mountain, Nevada, during 1992-1994. We defined a burrow as any underground chamber or tunnel greater than half the mid-carapace length (MCL) of the tortoise using it. Only data from tortoises located ≥ 50 times during an active season was used to determine number of burrows used per year. Tortoises used an average of 13.4 burrows/year (n=214, SD=3.9, range=5-23). Number of burrows used did not differ among sex and size classes (P=0.32) but did differ among years (P < 0.01); tortoises used an average of two fewer burrows in 1994 than in 1993. An average of 29% of the burrows used by each tortoise were > 1 m deep, 55% were < 1 m deep but deeper than the MCL of the tortoise, 12% were less than the MCL but deeper than half the MCL of the tortoise, and 4% were of unknown depth. In addition, we determined the number of new burrows (i.e., burrows not used in previous years by a tortoise) used each year by adult tortoises during 1993-1994. The number of new burrows used was calculated for tortoises that had ≥ 75 active-season locations prior to the year being evaluated. Tortoises used an average of 6.2 new burrows/year (n=81, SD=3.3, range =1-17). The number of new burrows used did not differ between sexes (P=0.58) but tortoises used an average of 2.8 fewer burrows in 1994 than in 1993 (P < 0.01). Of the new burrows used, 17% were > 1 m deep, 64% were < 1 m deep but deeper than the MCL of the tortoise, 17% were less than the MCL but deeper than half the MCL of the tortoise, and 2% were of unknown depth. (Authors) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*

134 BROWN, K.W., and D.D. SMITH. 1966. The poisonous plants of the U.S. Atomic Energy Commission's Nevada Test Site, Nye County, Nevada. SWRHL-33r, 65 pp.

This report provides a physical description, distribution, habitat, poisonous principle, symptomology, pathology, and treatment of affected animals, for 30 taxa of poisonous plants found on the Nevada Test Site. (TPO) *Keywords:* EPA*, vegetation*, ecology/ecosystem*, taxonomy*

135 BURDSALL, H.H. 2001. Fungal Species Found in Materials Collected from Several Substrates in Tunnel G of the Nevada Test Site. Bechtel Nevada, Las Vegas, NV.

Seventeen species of fungi were identified in samples collected by personnel of Bechtel Nevada from Tunnel G of the Nevada Test Site near Las Vegas, Nevada. Of the fungi identified fourteen were Deuteromycetes (asexual states), two Basidiomycetes and the other an Oomycete. Of the three air samples taken none produced fungal growth. The basidiomyctes are both brown rot decay fungi. However, only one of the dried specimens was in a fruiting condition, *Bourdotia eyrei*. In the case of the rest of the dried specimens identifications were made based on the partial characters. However, one of the attempts to culture the mycelial mats of this species was successful and it produced a basidiome in culture. Review of pertinent literature revealed that of the fungi identified, none are considered to put human health at particular risk. However, several of the genera found may occasionally cause an allergic reaction. (Author) *Keywords:* microbiota*, taxonomy*

136 BURGE, J.R., and C.D. JORGENSEN. 1973. Home range of small mammals: a reliable estimate. Journal of Mammalogy 54:483-488.

A method of estimating the probability of an animal being in a particular region of the home range is discussed. Data for *Perognathus longimembris* (Coues) were used to illustrate the use of this method and were transformed with $r' = (r - 1)/a$. One-sided tolerance limits were used to assert degrees of confidence Y that given percentages of the recaptures will be within specified distances from the estimated activity center. (TPO) *Keywords:* mammal*, ecology/ecosystem*, methods*

137 BURY, R.B., T.C. ESQUE, L.A. DEFALCO, and P.A. MEDICA. 1994. Distribution, Habitat Use, and Protection of the Desert Tortoise in the Eastern Mojave Desert. In: Biology of North American Tortoises. Bury, R.B., and D.J. Germano

(Eds.), Fish and Wildlife Research 13, U.S. Department of the Interior National Biological Survey, Washington, D.C.

The range of the desert tortoise (*Gopherus agassizii*) is widespread across the eastern Mojave Desert (southern Nevada, the Arizona Strip, and southwestern Utah). It occupies many habitats from flats and bajadas (hillsides) dominated by creosotebush at lower elevations (below 1,200 m elevation) to rocky slopes that border on blackbrush and juniper woodland at higher elevations (as high as 1,600 m). High mountain ranges, cold deserts, and playas (dry lake beds) are usually unsuitable habitat for tortoises. In winter, tortoises opportunistically use shallow burrows or deep caves, caliche overhangs, and rock crevices for cover. Although small isolated populations in the northern limits of the range may be prone to extirpation from cataclysmic stochastic events, deleterious effects of inbreeding depression may be mitigated by long generation times and relatively large home-range sizes of tortoises. Urbanization, roadways, habitat fragmentation, and other perturbations reduce wild populations. Because they may have unique local adaptations, small and peripheral populations of tortoises merit special protection. They are also protected by state and federal laws. We also urge protection of the tortoise in the eastern Mojave Desert because several large populations and many low - to moderate-sized populations still exist in remote areas and rugged terrain. (Authors) *Keywords:* desert tortoise*, ecology/ecosystem*

138 CARLSEN, T.M. 1996. Population and community ecology of the rare plant *Amsinckia grandiflora*. UCRL-LR–127218, Lawrence Livermore National Laboratory, CA.

Research was conducted between the fall of 1992 and the spring on the population and community ecology of the rare annual plant, *Amsinckia glandifloria* (Gray) Kleeb. Ex Greene (*Boraginaceae*). The research goal was to investigate the causes of the species rarity, data useful to restorative efforts. The work focused on the examination of competitive suppression by exotic annual grasses; comparisons with common, weedy congenera; and the role of litter cover and seed germination and seedling establishment. Annual exotic grasses reduced *A grandiflora* reproductive output to a greater extent than did the native perennial bunch grass. (Author) *Keywords:* invasive species*, sensitive plants*, annual plants*, perennial plants*, ecology/ecosystem*, life history*

139 CASTETTER, R.C., and H.O. HILL. 1979. Additions to the Birds of the Nevada Test Site, Western Birds, Vol. 10, pp. 221-223.

Since the establishment of the Nevada Test Site (112 km NW of Las Vegas) in 1950, there has been only one comprehensive study of the birds in its 3,500 km^2. Hayward et al. (1963) published the first report, which resulted primarily from the collection of 900 specimens. More recently, the birds in a *Larrea-Ambrosia* community of southwestern NTS have been well documented by Herbert O. Hill (1971, 1972, 1973) under the International Biological Program/Desert Biome studies. The nature of work carried on here by the Energy Research and Development Administration (ERDA) makes it impossible to allow unrestricted access to ornithologists. A note by Banks and Hensen (1970) on some unusual birds at the Corn Creek Field Station of the Desert National Wildlife Range (77 km SE of NTS) states that the Las Vegas Valley may provide a natural flyway for migrating birds. If so, then NTS is a likely stopover for many of them. Indeed, the construction of sewage holding ponds and wells on NTS appears to have attracted many species and densities which would otherwise not be expected in the area. Goldfish (*Carassius auratus* and *Notemigonus crysoleucus*) occur in many of the ponds and wells. Great Blue Herons (*Ardea herodias*) have been observed feeding on these fish. Certain other birds must also take advantage of these stocked waters. We have seen as many as 197 waterfowl at one time on the 2.9 ha Mercury sewage ponds. located at the southern tip of NTS. The following additions represent several years of casual observation at NTS. In future years more new species will undoubtedly be seen. Our records indicate that approximately 30 of the previously recorded 190 birds of NTS require revision as to seasonal and/or breeding status. More field work should be done, particularly in the northern portions of the Test Site. (Authors) *Keywords:* fish*, bird*, taxonomy*

140 CHAMBERLIN, R.V. 1962. Millipeds from the Nevada test area. Proceedings of the Biological Society of Washington 75:53-55.

Arinolus sequens, A. nevadae, Orthichelus michellbacheri (hitherto known from only 2 specimens), and *Titsona tida* were collected. (AKW) *Keywords:* invertebrate*, taxonomy*

141 CHAMBERLIN, R.V. 1962. New records and species of chilopods from Nevada and Oregon. Entomol. News 73:134-138.

Ten spp. with collection data and other notes are listed as records: *Nyctunguis stenus*, Clark Co., Nevada; *Oabius wamus*, Saddleback Mt., Oregon; *O. mercurialis*, Clark Co., Nevada; *Pokabius utahensis tidus*, Saddleback Mt., Oregon. A tentative key distinguishing 15 spp. of *Nyctunguis* is given. (JLW) *Keywords:* invertebrate*, taxonomy*

142 **CHAMBERLIN, R.V. 1963. A new genus in the chilopod family Tampiyidae. Proceedings Biological Soc. Wash. 76:33-35.**

Eremorus with type *E. becki* from the Nevada test area is described, with key to distinguish 3 genera of Tampiyidae. (AKW) *Keywords:* invertebrate*, taxonomy*

143 **CHAMBERLIN, R.V. 1965. A new genus and species in the chilopod family Tampiyidae. Great Basin Naturalist Memoirs 25:39-42.**

Abatorus allredi, a new species in the chilopod family Tampiyidae was described from material collected on the Nevada Test Site, Nye County, Nevada in December, 1961 (TPO) *Keywords:* invertebrate*, taxonomy*

144 **CHARLET, T.N., S.R. ZITZER, W.E. SMITH, and S.D. SMITH. 2000. The effects of elevated CO_2 on insects at the Nevada Desert FACE Facility. In: Symposium Abstracts, The Ecological Society of America 85th Annual Meeting, August 6-10, 2000, Snowbird, UT.**

While some research has examined the effects of elevated CO_2, on insects, most has focused on agriculturally important species and has been conducted in glasshouses. In this study we present data on insects collected at the Nevada Desert FACE Facility (NDFF) during the growing season of 1998, a wet year with above average primary production. FACE (Free-Air-CO_2-Enrichment) technology allows a unique opportunity to study the effects of elevated CO_2 on a natural ecosystem without barriers to insect movement and without providing an artificially warm or humid environment. Bimonthly, sticky-traps were placed for a period of one week in the upper canopy of 5 species of Mojave Desert plants including an evergreen shrub (*Larrea tridentata*), two deciduous shrubs (*Lycium pallidum* and *Ambrosia dumosa*), and two grasses (*Pleuraphis rigida* and *Achnatherum hymenoides*). Of 13 insect orders identified, 5 orders made up 95% of all the insects collected. These five (Collembola, Diptera, Homoptera, Hymenoptera, Thysanoptera) were included in further analyses. We did not observe a significant difference in the number of insects in the elevated CO_2 rings versus ambient rings, nor between the blowing and non-blowing ambient rings. Significant effects were observed in the collection date for all orders of insects, most dramatic was the sudden increase of Collembola (7,000%) and the sudden decrease of Thysanoptera (6,500%) June 15-21. Significant effects were also observed in host plant use by different insect orders. Thysanoptera (thrips) were highest on shrub species while Collembola (springtails) were most abundant on grass species. Homoptera (leaf-hoppers) were common on all host species except *Larrea* while Diptera (flies) were most abundant on *Lycium*. The absence of CO_2 treatment effect on the number of insects suggests that we may not see any differential effects on pollination, foliar damage or predation in, this ecosystem, but it also could be due to the fact that this ecosystem had experienced only one year of elevated CO_2 treatment at the time of the study. (Authors) *Keywords:* FACE*, perturbations*, perennial plants*, annual plants*, invertebrate*, ecology/ecosystem*

145 **CHEW, R.M. 1975. Effect of Density on the Population Dynamics of *Perognathus formosus* and its relationships within a desert ecosystem. US/IBP Desert Biome Res. Memo. 75-18. Utah State University, Logan, 7 pp.**

In April 1973 the populations of *Perognathus formosus* in Plot C in Rock Valley were artificially increased. Herb and seed production were very high in 1973 and the introduced mice survived and reproduced, building up a peak density of 49 mice/ha in August. These populations were censussed during 1974 and in April 1975, in both the experimental half of Plot C with sheet metal barriers (southern) and the control half (northern). In March 1974, densities in Plot C were 33.6/ha (S) and 33.9/ha (N), and an estimated 2/ha in Plot A, which has never been manipulated. Although some mice became sexually active in the spring in Plot C, no pregnant females or young animals were captured. In the absence of reproduction, densities declined to 19.6 (S) and 23.5/ha (N) in August 1974 and 6.1 (S) and 7.2/ha (N) in April 1975. In April, 90% of males and 57% of females were sexually active; 27% of females were pregnant. In Plot A each female produced about nine young in 1974. Herb production was 23.3 kg/ha in the spring of 1974, compared to 4.5 kg/ha in 1972, when pocket mouse reproduction was good, and 802 kg/ha in 1974 when reproduction was very high. Mean monthly body weights were significantly lower every month in 1974 than in 1972. The accumulated data for Rock Valley indicate that the reproductive success of *P. formosus* is principally limited by population density at the beginning of the breeding season, in an inverse fashion. Whenever spring densities have been higher than 27 kg/ha, there has been no reproduction. The quantity of herb production seems to have little effect except when it is exceptionally high. Very high herbage production apparently mitigates density effects and permits good reproduction. The test of the hypothesis that the density-dependent effect is the result of behavioral interactions of pocket mice was inconclusive. (Author) *Keywords:* IBP*, mammal*, ecology/ecosystem*, life history*

146 **CHEW, R.M., and J.F. NELSON. 1975. Factors affecting seed reserves in the soil of a desert ecosystem. US/IBP Desert Biome Res. Memo. 75-17. Utah State University, Logan, 17 pp.**

During a second year (1972) of low herb production, there was a significant variation of seed reserves in the upper 2 cm of soil, with a doubling from February to June and a density-independent halving by October. In October there were 8×10^6 seeds/ha (5.3 kg/ha). After favorable fall and winter rains, seed densities in October 1973 were 10-16 times greater under shrubs and 23-27 times greater in exposed areas (together as high as 187.5×10^6 seeds/ha, 84.3 kg/ha). The increase involved principally the winter annual grass, *Festuca octoflora*. In 1972, when there was a small difference in rodent density between two plots (0.8:1.0). there was no effect of plot on seed density. In 1973, when there was a 1:17.8 ratio of rodent densities, there was a significant effect of plot on seed densities under shrubs. From October 1973 to October 1974, seed reserves in exposed areas decreased by 20% in the plot with few rodents, and 40% in the one with many. Consumption of seeds by rodents is probably an important factor in the decrement of seed reserves, accounting for 30 to 80% of the decreases in this study. There is slight evidence that pocket mice differentially decrease the abundance of the heavier species of seeds. Seed density was significantly greater under shrubs than in interspaces; density was significantly correlated with the size of the shrub canopy. There was a significant effect of the species of shrub on the density of total seeds, shrub seeds and seeds of the more abundant herb species, possibly due to different soil conditions created by different shrubs, and to specific differences in canopies. During years of low herb production, the undershrub areas are a refuge of seed production by herbs, and shrub seeds form a larger portion of recruitment and future seed reserves. The difference in response of shrubs and herbs to weather increases the stability of seed reserves. In May 1973, the density and biomass of herbs were significantly greater under shrubs than in interspaces. The ratio (number of herbs in May to the number of seeds the previous October) x 100, was 16.8 under shrubs and 43.6 in the interspaces. This minimum germination (38%)- over the whole habitat) may have been sufficient to account for most of the decrease of seeds in the plot with little consumption by rodents. It takes an exceptional coincidence of events, even in deserts, to cause a severe depletion of seed reserves. (Authors) *Keywords:* IBP*, annual plants*, perennial plants*, mammal*, ecology/ecosystem*

147 **CHEW, R.M., and F.B. TURNER. 1974. Effect of Density on the Population Dynamics of *Perognathus formosus* and its relationships within a desert ecosystem. US/IBP Desert Biome Res. Memo. 74-20. Utah State University, Logan, 9 pp.**

In a 1972 field study at Rock Valley in which enclosed populations of *Perognathus formosus* were artificially increased, sexual activity and survival were inversely related to density. Using the same enclosures (each of 4.43 ha), the 1973 experiment was designed to test the hypothesis that carrying capacity of ecosystems for *P. formosus* is limited by density, through behavioral interactions in their overlapping home ranges. Interaction of individuals was artificially reduced in the southern enclosure by installing 60 metal barriers 15.2 m long by 31.5 cm high in a semi-grid pattern, while the northern enclosure was left as the control. Pocket mice were introduced to the enclosures during April, May and June to raise the density to 27/ha, so that natural reproduction would then elevate density beyond carrying capacity (56/ha maximum previously recorded in 1966). The population curves of the two enclosures were not significantly different through to October 12; the peak densities were 98 and 87/ha in the north and south enclosures, respectively. Attainment of such high densities is attributed to the unusually favorable vegetative season of 1973, such that adequate food resources mitigated effects of stress from intraspecific interactions and prevented the populations from reaching equilibrium levels during the experiment. These factors confounded a satisfactory testing of the hypothesis. The barriers tended to reduce the home range of introduced male mice, and also reduced stress on the southern population of males which retained their sexual activity longer than northern males. Though no young males became sexually active in the northern enclosure, 48 did so in the barrier treatment enclosure. Less stress in the southern enclosure is further evidenced by the significantly greater movement across the imperfect partition from north to south than vice versa. Contrary evidence for this stress differential is noted by the facts that in the northern enclosure the females were more sexually active and a higher density developed. In general, the data do not support the hypothesis. (Authors) *Keywords:* IBP*, mammal*, ecology/ecosystem*, life history*

148 **CHEW, R.M., F.B. TURNER, P. AUGUST, B. MAZA, and J. NELSON. 1973. Effect of density on the population dynamics of *Perognathus formosus* and its relationships within a desert ecosystem. US/IBP Desert Biome Res. Memo. 73-18.**

Utah State University, Logan, 32 pp.

The population dynamics of *P. formosus* were observed in 3 enclosures, which initially had densities of this pocket mouse in a ratio of 10:4:1. The high density was obtained by adding, mice, the medium density by reducing natural number by half. The low density occurred naturally and was near the extinction level; reproduction, in this population began late, but then continued longer. Density dependent effects were observed. The relative amount of sexual activity (incidence X duration) was inversely related to density. The number of young weaned per successful pregnancy was highly correlated with density r^2 = -0.999). At the low density all pregnancies were successful and all young were weaned. Survival of resident mice (RS) was high and unaffected by density. Survival of introduced mice (INT) was lower and inversely related to density. The first mice born survived as well as RS, but survival of later cohorts was less and was inversely related to density. The integration of these effects was that the artificial increase was not maintained and the reduced population quickly recovered. After the late start the low density population increased continuously, but it never reached carrying capacity. A growth curve is given for mice 20-140 days old in the field. Males grew more rapidly than females; in some comparisons growth rate was inversely related to density. Survival is affected by experience with an area, sudden introduction into a foreign area, density, and ranges. The observed density effects may result from interactions of mice in overlapping home ranges. Home range was negatively correlated with density. We hypothesize that if sensory perception of the mice can be reduced, and interaction thus be reduced, carrying capacity will be increased. This will be tested in 1973. In February 1972 seed density was an average of 832 seeds/m^2 of habitat, or about 416 kg/ha. Seed density was significantly higher under shrubs and was directly related to canopy size; in the open areas, seed density was inversely related to distance from shrubs. (Authors) *Keywords:* IBP*, vegetation*, mammal*, ecology/ecosystem*, life history*

149 **CHILTON, B.D., H.A. PFUDERER, and T.L. COX. 1989. Nevada Applied Ecology Group Publications. NVO/AEIC-264, CIC 00174063. Nevada Applied Ecology Information Center, Oak Ridge National Laboratory, Oak Ridge, TN.**

Since January 1972, the Nevada Applied Ecology Information Center (NAEIC), Information Research and Analysis Section, Health and Safety Research Division, Oak Ridge National Laboratory, has provided technical information support to the Nevada Applied Ecology Group (NAEG) relevant to the behavior of specific radionuclides, primarily plutonium and americium, in the environment, with special emphasis on pathways to man. This bibliography represents a summary of the biomedical and environmental studies conducted by the NAEG and its contractors. The bibliography focuses on research sponsored by the NAEG. Subject areas of the publications include cover studies of soil, vegetation, animals, microorganisms, resuspension, and meteorology. All references in this publication are stored in a computerized form that is readily available for searches upon request to NAEG and its contractors. (Authors) *Keywords:* NAEG*, bibliography*

150 **CHRISTIANSEN, R.L., F.G. POOLE, H. BARNES, P.P. ORKILD, F.M. BYERS, Jr., W.J. CARR, F.A. McKEOWN, F.N. HOUSER, E.M. SHOEMAKER, and W.L. EMERICK. 1969. Guidebook for past field trips to the Nevada Test Site. USGS Open File Report, 57 pp.**

Three topically oriented field trips are described. An examination of the thick miogeosynclinical section of Paleozoic rocks and some of the post-Paleozoic structural features were conducted on the first trip. The Timber Mountain caldera field trip is described. It is an assemblage of rocks of several thousand square miles in southern Nye County, Nevada. The last field trip guide features the observation of effects of explosions. Maps of all areas are included. (JCW) *Keywords:* geology*

151 **CLARKSON, W.W., L.R. KRUMHOLZ, and J.M. SUFLITA. Anaerobic Bacterial Quantitation of Yucca Mountain, Nevada DOE Site Samples. 1996. In: High Level Radioactive Waste Management. Proceedings of the Seventh Annual International Conference, Las Vegas, NV, April 29 - May 3, 1996, pp. 39-40. American Nuclear Society; American Society of Civil Engineers, La Grange Park, IL.**

Anaerobic bacteria were studied from samples of excavated rock material as one phase of the overall Yucca Mountain site characterization effort. (Authors) *Keywords:* YMSCO*, geology*, microbiota*, ecology/ecosystem*

152 **COCHRANE, S. 1979. Status of Endangered and Threatened Plant Species on Nevada Test Site - a Survey. Parts 1 and 2. Appendix C: Collection Records for the Taxa Considered. EG&G Report No. 1183-2356. Santa Barbara, CA.**

This inventory of herbarium collections is a compilation of information on plant specimens seen by the author in major herbaria of California, Nevada, and Utah, and in the Missouri Botanical Garden and the U.S. National Herbarium. Other information garnered from individuals and from records listed in Beatley, 1977 a, b, and c is also included. The report is meant to provide more precise species locations and distribution data to assist those making decisions about species status, so that protective measures can be taken when deemed necessary. Because of these more specific objectives and content, this appendix has not been distributed to all recipients of Parts 1 and 2 of the Report. (Author) *Keywords:* sensitive plants*, taxonomy*, ecology/ecosystem*

153 **COLE, A.C. 1963. A new species of *Veromessor* from the Nevada Test Site and notes on related species (Hymenoptera: Formicidae). Ann. Entomol. Soc. Amer. 56:678-682.**

Four species of *Veromessor* are known from the Nevada test site, namely *pergandei* Emery, *lariversi* M. R. Smith, *lobognathus* (Andrews), and *smithi*, n. sp. The new species is described from all three castes, the sexual castes of *lariversi* and *lobognathus* are described, the four species are keyed, and essential features of the workers and males are figured. (Author) *Keywords:* invertebrate*, life history*, taxonomy*

154 **COLE, A.C. 1965. Discovery of the worker caste of *Pheidole (P.) inquilina*, new combination (Hymenoptera: Formicidae). Ann. Entomol. Soc. Amer. 58:173-175.**

All castes of *Pheidole inquilina* (Wheeler) new combination, including the soldier which is reported for the first time, were found in nests of *Pheidole pilifera coloradensis* Emery, a host species, at the Nevada Test Site. The soldier is described and figured. The finding of the soldier, with its obvious *Pheidole* characteristics, has made it necessary to transfer *inquilina* to the genus *Pheidole* Westwood and to synonymize the monobasic genus *Epipheidole* Wheeler. (Author) *Keywords:* invertebrate*, life history*, taxonomy*

155 **COLE, A.C., Jr. 1966. Ants of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 7(3), 27 pp.**

Description for 57 taxa of the family Formicidae is given as part of the ecological studies of the Nevada Test Site. Collection was made from can traps and field collections. Geographic areas and plant communities were described along with the inventory of ants. (BBM) *Keywords:* invertebrate*, ecology/ecosystem*, taxonomy*

156 **COLLINS, E., and T.P. O'FARRELL. 1984. Surveys for Plant Species of Concern on Northern and Eastern Yucca Flat, Nevada Test Site, Nye County, Nevada. EGG 10282-2039, EG&G Energy Measurements, Santa Barbara Operations, Goleta, CA, 17 pp.**

Ground surveys of the northern and eastern portions of the Yucca Flat drainage basin on the U.S. Department of Energy's Nevada Test Site, Nye County, Nevada, were conducted to determine the distribution of rare plants, or species of concern. This information was needed to help DOE evaluate whether all proposed surface disturbances in the basin must be preceded by a preconstruction survey to assess possible impacts on species of concern. Fourteen areas in both bajada and mountainous habitats were surveyed between August 11 and 25, 1983. Six species of concern were found at 11 localities in mountainous terrain, but none were found on bajadas. (Authors) *Keywords:* sensitive plants*, ecology/ecosystem*

157 **COLLINS, E., and T.P. O'FARRELL. 1985. 1984 Biotic Studies of Yucca Mountain, Nevada Test Site, Nye County, Nevada. EGG 10282-2057. EG&G Energy Measurements Santa Barbara Operations, Goleta, CA.**

A portion of Yucca Mountain on and adjacent to the U.S. Department of Energy's Nevada Test Site, Nye County, Nevada, is being considered as a possible location for a national high-level radioactive waste repository. The geologic and environmental characteristics of the site are being investigated to determine its suitability for further characterization. Goals of biotic studies were to identify species of concern, describe major floral and faunal associations, determine exposure levels of external background radiation, and assess possible impacts of characterization and operational activities. The species composition of dominant small mammals inhabiting major vegetation associations in 1984 varied little compared with results of similar surveys conducted in 1982 and 1983. Total captures were lower than in previous years, and there was circumstantial evidence indicating that reproduction, especially in pocket mice, was curtailed. Merriam's kangaroo rat and the long tailed pocket mouse continued to be the most abundant species trapped, although the latter was less abundant than in previous years. Diversity of resident species did not differ significantly between the trapping lines and varied between 6 and 8. The composition and relative abundance of associated species was more variable. Western harvest mice were trapped for the first time, but pinyon mice, which were present in prior years, were not trapped. Estimated external gamma radiation exposure doses to resident kangaroo rates averaged 10.7 and 12.9 mR per month in May and June, respectively. Within each month, exposure doses were not significantly different between the six locations sampled. Five desert tortoises were observed during surveys of possible sites for repository surface facilities; two were found in areas where there was previous evidence of active tortoises, and three others where evidence of tortoise activity was sparse in previous years. The overall results of surveys indicated, however, that tortoise densities were low and similar to estimates made in previous years. No new species of concern were found in the study area, but a kit fox and evidence of bobcats were observed for the first time. No activities associated with geologic and environmental investigations had a demonstrable negative effect on species of concern. (Authors) *Keywords:* YMSCO*, sensitive plants*, sensitive animals*, desert tortoise*, mammal*, ecology/ecosystem*, radiation*

158 COLLINS, E., and W.A. RHOADS. 1981. Field surveys for *Lathyrus hitchcockianus* at the Nevada Test Site and Bullfrog Hills. EG&G Energy Measurements, Santa Barbara Report No. EGG 1183-2431.

Surveys were carried out in May and June 1981 to determine the distribution of *Lathyrus hitchcockianus* (Mojave Sweetpea) on Yucca Mountain, and to monitor the condition of known populations in the Bullfrog Hills, Nye County, Nevada. No *Lathyrus* was discovered in the southern and central sections of Yucca Mountain, but the small, previously documented population at Beatty Wash saddle in the northern portion of Yucca Mountain was relocated. (Authors) *Keywords:* YMSCO*, sensitive plants*, ecology/ecosystem*

159 COLLINS, E., T.P. O'FARRELL, and W.A. RHOADS. 1981. Annotated Bibliography for Biological Overview for the Nevada Nuclear Waste Storage Investigations, Nevada Test Site, Nye County, Nevada. EGG 1183-2419, S-713-R. EG&G Energy Measurements, Goleta, CA, pp. 43.

This report contains an evaluation of current literature dealing with the flora and fauna within the Yucca Mountain project area that might prove to be useful in assessing potential project impacts. Evaluation of the relevant literature was designed to: (1) note whether information on flora and fauna, habitat requirements, distribution, abundance, importance to the ecosystem, and sensitivity to perturbations is sufficient to support environmental impact analyses; (2) determine whether sensitive species (i.e., threatened or endangered species, game animals, legally protected species) might be located in the project area; (3) identify significant gaps in biological information, and (4) recommend further studies

needed to provide sufficient data for environmental impact assessments. (Authors/WKO) *Keywords:* YMSCO*, bibliography*, sensitive animals*, sensitive plants*, vegetation*, vertebrate*, ecology/ecosystem*

160 COLLINS, E., T.P. O'FARRELL, and W.A. RHOADS. 1982. Biologic Overview for the Nevada Nuclear Waste Storage Investigations, Nevada Test Site, Nye County, Nevada. EGG 1183-2460, S-752-R. EG&G Energy Measurements, Goleta, CA.

The major objective of this study was to compile and evaluate the available literature dealing with the ecological characteristics of a 200-sq-mi portion of the southwestern Nevada Test Site (NTS) under consideration for siting a high-level radioactive waste repository. Specific goals were to evaluate whether the available information was sufficient to(1) support environmental impact assessments, (2) determine whether sensitive species might be present, and (3) recommend further studies needed to provide data to fill gaps in the ecological information. The Nevada Nuclear Waste Storage Investigations (NNWSI) project study area includes five major vegetation associations characteristic of the transition between the northern extent of the Mojave Desert and the southern extent of the Great Basin Desert. A total of 32 species of reptiles, 66 species of birds, and 46 species of mammals are known to occur within these associations elsewhere on the NTS. Ten species of plants, and the mule deer, wild horse, feral burro, and desert tortoise were defined as possible sensitive species because they are protected by federal and state regulations, or are being considered for such protection. The major agricultural resources of southern Nye County included 737,000 acres of public grazing land managed by the Bureau of Land Management (BLM), and 9500 acres of irrigated crop land located in the Beatty/Oasis valleys, the Amargosa Valley, and Ash Meadows. Range lands are of poor quality. Alfalfa and cotton are the major crops along with small amounts of grains, Sudan grass, turf, fruits, and melons. The largest impacts to known ecosystems are expected to result from: extensive disturbances associated with construction of roads, seismic lines, drilling pads, and surface facilities; storage and leaching of mined spoils; disposal of water; off-road vehicle travel; and, over several hundred years, elevated soil temperatures. Significant impacts to off-site areas such as Ash Meadows are anticipated if new residential developments are built there to accommodate an increased work force. Several species of concern and their essential habitats are located at Ash Meadows. Available literature contained sufficient baseline information to assess potential impacts of the proposed project on an area-wide basis. It was inadequate to support analysis of potential impacts on specific locations selected for site characterization studies, mining an exploratory shaft, or the siting and operation of a repository. (Authors) *Keywords:* YMSCO*, desert tortoise*, sensitive animals*, sensitive plants*, vegetation*, vertebrate*, ecology/ecosystem*

161 COLLINS, E., T.P. O'FARRELL, and M.L. SAULS. 1983. Survey for Desert Tortoise on the Possible Site of a High-Level Nuclear Waste Repository, Nevada Test Site. In: The Desert Tortoise Council Proceedings of 1983 Symposium, pp. 19-26. Desert Tortoise Council, Inc., Long Beach, CA.

A survey was conducted between 29 March and 28 May 1982 to determine the distribution and density of desert tortoise (*Gopherus agassizii*) in the vicinity of Yucca Mountain on the Nevada Test Site, an area under study as a'potential high-level nuclear waste repository. Desert tortoise sign, including sign in predator scats and on Neotoma lepida middens, was recorded along 129 straight-line transects. Transects were generally spaced 200 yards apart and were 1 to 3 mi long. In a total of 197.5 mi of transects completed in the 27.5-mi^2 project area, 208 sign, comprised mainly of scats and remains, were observed; only one live tortoise was found. Sign was observed at elevations between 3,200 and 5,240 ft in vegetation ranging from *Larrea* associations on flats to mixed transition and *Coleogyne* associations on slopes. Due to the relatively low estimated population density observed, and the mitigation activities conducted by the U.S. Department of Energy, no significant impacts to the species are anticipated from the proposed project. (Authors) *Keywords*: YMSCO*, desert tortoise*, ecology/ecosystem*

162 DAVIS, M.A., S. MARTIN, A. MIRANDA, and J.M. HORN. 1998. Sustaining Native Microbial Growth With Endogenous Nutrients at Yucca Mountain. Presented at: 1998 International High-Level Radioactive Waste Management Conference, Las Vegas, NV, 11-14 May 1998. UCRL-JC–129185, Lawrence Livermore National Laboratory, Livermore, CA.

The integrity of candidate waste package materials for the proposed Yucca Mountain (YM) repository may be compromised by the corrosive activities of microorganisms. Bacterial activities will be dependent on the abilities of deleterious bacteria to grow and multiply in the repository environment. Therefore, preliminary to assessing microbial induced corrosion, experiments were undertaken to determine the growth of native YM bacterial communities in modified YM pore water. Specifically, we sought to define nutrients that limit bacterial growth in Yucca Mountain and determine growth rates under aerobic, saturated conditions. (Authors) *Keywords:* YMSCO*, microbiota*, nutrition/diet*, life history*

163 DEFALCO, L.A., and R.S. NOWAK. 2000. Plant-plant interactions in a Mojave Desert plant community exposed to elevated atmospheric CO_2 during a year with above-average precipitation. In: Symposium Abstracts, The Ecological Society of America 85th Annual Meeting, August 6-10, 2000, Snowbird, UT.

Desert ecosystems are expected to have large increases in plant productivity as atmospheric CO_2 rises because greater plant water use efficiency should increase soil moisture. The growth responses of plants to elevated CO_2 are complex, especially in natural plant communities where different growth forms interact to acquire limited soil moisture. We examined plant-plant interactions in an intact Mojave Desert ecosystem using FACE (Free Air CO_2 Enrichment) technology. We measured the absolute growth rate (AGR) and reproductive effort (number of flowers/maximum biomass) of target individuals of two C_3 species: *Eriogonum trichopes* (annual forb) and *Achnatherum hymenoides* (perennial grass). We also quantified the change in plant cover surrounding targets for analysis in a multiple linear regression to determine whether these neighbors influenced target plant performance under elevated (550 μmol mol^{-1}) and ambient CO_2 concentrations. Eriogonum AGR and reproductive effort were not significantly different between CO_2 treatments because this annual species completed its life cycle during the spring when above-average precipitation maintained high soil moisture. While the four dominant annual species surrounding *Eriogonum* targets increased in canopy cover under elevated CO_2 the total cover of all annual plant species was not significantly different between CO_2 treatments. Thus, species composition and growth response differed among neighbor annual species under elevated CO_2. *Achnatherum* AGR was significantly greater under elevated CO_2, and this enhanced response occurred in summer when soil moisture became more limited. Although neighbor grasses and forbs did not have an effect on *Achnatherum* performance, the cover of neighbor perennial shrubs and grasses was associated with a reduction in AGR, and this effect was greater under elevated CO_2, As CO_2 continues to rise, differences in the responses of species in mixed communities to available moisture will likely influence future plant communities of arid systems. (Authors) *Keywords:* FACE*, perturbations*, annual plants*, perennial plants*, ecology/ecosystem*, life history*

164 **DEFALCO, L.A., and R.S. NOWAK. 2000. Plant-plant interactions within an intact community exposed to elevated atmospheric CO_2 at the Nevada Desert FACE Facility. FACE 2000 Conference, June 27-30, 2000, Tsukuba, Japan.**

Growth responses of plants exposed to elevated CO_2 are difficult to interpret for mixed plant communities because resources acquired for growth by a single plant may be used by one or more neighbors. The development of FACE (Free Air CO_2 Enrichment) technology has made possible the examination of the effects of elevated CO_2 on intact plant communities. We measured the production of two perennial grasses growing in association with a non-native annual grass at the Nevada Desert FACE facility during spring 1998. The leaf biomass that accumulated during the growing season (=peak biomass) was measured in *Achnatherum hymenoides* (early season grass) and *Pleuraphis rigida* (late season grass) for an intact Mojave Desert plant community that was continuously fumigated at elevated (550 µmol mol^{-1}) or ambient CO_2 concentration since April 1997. Plant cover of neighboring *Bromus madritensis* (an annual grass introduced into North America at the turn of the century) was also measured. We determined (1) whether decreasing peak biomass of perennial grasses was associated with an increase in *Bromus* cover, and (2) whether CO_2 fumigation influenced the relationship between peak biomass of perennial grasses and cover of neighboring *Bromus*. *Achnatherum* peak biomass was negatively associated with *Bromus* cover under ambient CO_2, but this relationship was positive under elevated CO_2. *Pleuraphis* peak biomass was neither positively nor negatively associated with *Bromus* cover under either CO_2 concentration. We discuss the difficulties to understanding plant-plant interactions in intact plant communities fumigated with elevated CO_2. (Authors) *Keywords:* FACE*, perturbations*, invasive species*, annual plants*, perennial plants*, ecology/ecosystem*, life history*

165 **DINGMAN, R.E., and J. BANDOLI. 1973. Density and dietary habits of pocket gophers (*Thomomys bottae centralis*) in Rock Valley. US/IBP Desert Biome Res. Memo. 73-21. Utah State University, Logan, 12 pp.**

In July and August, 1972, a field and laboratory project was conducted near Plot C, UCLA/CETO enclosure, Rock Valley, on the AEC test site near Mercury, Nevada. This project was to determine the density of the population of Botta's Pocket Gophers (*Thomomys bottae centralis*) in this region, their daily food consumption and dietary references. Density was estimated by live trapping and burrow excavation. Results indicate a density of 3.8 *T. bottae*/ha having a biomass of 270.0 g/ha. Food consumption tests were conducted in the laboratory by measuring amounts of native vegetation (*Ephedra nevadensis; Franseria dumosa*, *Lycium andersonii*, *L. pallium*, *Larrea divaricata*, *Coleogyne ramosissima*) cut (cropped), consumed and metabolized per day. Results indicate that a *T. Bottae* in Rock Valley cuts 25.4 g/day, consumes 23.9 g/day and metabolizes 20.4 g/day of the above vegetation. This indicates that about 121.5 g/ha/day is cut by *T. bottae*. Food preference was determined by presenting measured amounts of the above plants to captive pocket gophers and comparing species amounts consumed to total amount consumed. The most preferred food plant appears to be *E. nevadensis*, with *F. dumosa* second. Because of small sample size (difficulty of collecting animals because of seasonal inactivity) the above results are considered crude estimates, but they do indicate density, food consumption and preference. (Authors) *Keywords:* IBP*, perennial plants*, mammal*, nutrition/diet*, ecology/ecosystem*

166 **DINGMAN, R.E., and L. BYERS. 1974. Interaction between a fossorial rodent (the pocket gopher, *Thomomys bottae*) and a desert plant community. US/IBP Desert Biome Res. Memo. 74-22. Utah State University, Logan, 6 pp.**

Commencing in June, 1973, additional studies on the density, food consumption and dietary preferences of Botta's Pocket Gopher (*Thomomys bottae centralis*) were made in Rock Valley, near Mercury, Nye County, Nevada. Density was determined by excavation and mapping of burrow systems. Results indicate a density of 4.7 *Thomomys bottae* per hectare, having a biomass of 365.7 grams per hectare live weight, or 109.5 grams per hectare dry weight. Food consumption tests in the laboratory were conducted by presenting measured amounts of native vegetation known to be eaten by *Thomomys bottae* in the field. The amounts of food consumed and metabolized per day were estimated from these data. Results indicate consumption of 16.6 grams dry weight per day, and metabolism of 12.8 grams per day of the native vegetation by each *Thomomys bottae*. Food preference was determined by presenting measured amounts of native vegetation to captive *T. bottae* and comparing the amount consumed with the amount presented. The most preferred food plant appears to be *Lycium andersonii*, with *Eriogonum brachypodum* second. In an attempt to assess the effects of grazing or cropping by *Thomomys bottae* on *Ephedra funerea*, a plot was established and of the 60 plants in the plot, 10 were left untouched, 10 were cut 25% of their volume, 10 were cut 50%, 10 were cut 75% and 20 were cut 100%. In another area of 3,600 m^2, four *Thomomys bottae* were introduced to determine the effect of increased density on the vegetation. Results of the latter two manipulations are incomplete as yet. (Authors) *Keywords*: IBP*, perennial plants*, mammal*, nutrition/diet*, ecology/ecosystem*

167 DINGMAN, R.E., and L. BYERS. 1975. Interaction between a fossorial rodent (the pocket gopher, *Thomomys bottae*) and a desert plant community. US/IBP Desert Biome Res. Memo. 75-23. Utah State University, Logan, 6 pp.

Previous studies in Rock Valley, near Mercury, Nye County, Nevada, indicated Botta's pocket gopher (*Thomomys bottae centralis*) was a significant component of the biomass of terrestrial vertebrates. Favored foods are *Ephedra funerea* and *E. nevadensis*, which are frequently damaged severely by cropping. To assess the effect of this cropping on the success and distribution of *Ephedra*, two studies were initiated. In an artificial grazing study, *E. funerea* plants were cut 0, 25, 50, 75 and 100% of their above-ground volume and monitored for primary production and shoot growth. Shoot growth and primary production were lowest in *E. funerea* cut 100% ,shoot growth highest in those cut 75% , primary production highest in those cut 50% and 25%. In the UCLA/CETO enclosure, Plot C, a manipulative study was conducted by removing 18 pocket gophers from the north side while leaving 11 pocket gophers in place on the south side of the plot (overall density 3.3 gophers/ha, mean live weight 76.0 ± 18.8 g, mean dry weight 22.8 g). A survey of plants made four months after the initiation of the trapping program indicated a significantly greater number of damaged plants on the south side than on the north ($P < .005$). New stem production was higher on the south side. Visual assessment of damage utilized the method developed in the artificial grazing study. Density and biomass of *E. funerea* on the study plot were: 866.7 plants/ha, 742.2 kg/ha, 0.54488 ± .26472 kg mean plant weight. Density and biomass of *E. nevadensis* were: 308.2 plants/ha, 128.13 kg/ha, 0.41573 ± .25664 kg. No method was devised to relate distribution of *Ephedra* to the distribution of *T. bottae*. (Authors) *Keywords:* IBP*, perennial plants*, mammal*, ecology/ecosystem*, nutrition/diet*

168 DROUET, F. 1960. Algal Flora of the Nevada Test Site. The Colorado-Wyoming Academy of Science 4:3.

About thirty species of algae, exclusive of diatoms, have appeared among the collections from the Nevada Test Site. Of these, half are aquatic plants found only in Cane Springs. The other half inhabit the soil crusts of Yucca, Frenchman and Jackass Flats and the Pahute mesa. Six of the terrestrial species have not been seen forming natural growths, but have appeared in laboratory cultures. The remaining soil algae are well distributed through the area. *Microcoleus vaginatus* may be found almost anywhere on the surface of soil not disturbed by ants or larger animals. On the playas only sparse growths of this species and of diatoms have appeared. At the edges of the playas, and especially in the washes which empty into the playas during rainy seasons, crusts of algae cover every slight depression where water has stood. The various species of *Schizothrix* and *Microocoleus* compose these crusts. Similar precocious developments of algae are found in the rain pools in rocks on Pahute mesa, but with the addition of N*ostoc* spp. and *Protococcus Grenville*. Near the hills which surround the flats mosses and algae form continuous thick crusts on the ground. The algae involved are the aforementioned species of *Schizothrix* and *Microcoleus*, together with *Nostoc commune*, in various stages of parasitization by fungi, and *Scytonema hofmannii*, on the surfaces of the lichens. The same species of *Schizothrix* and *Microcoleus* sooner or later develop crusts in the bottoms of temporary rain pools in roadside ditches, excavations, gravel pits, and even in such minor depressions as automobile tracks and the hoof-prints of cows and horses. (Author) *Keywords:* wetlands*, microbiota*, taxonomy*

169 DUNAWAY, P.B., and E.R. SOROM. 1982. Experience in Cleanup of Old Radioactive Sites. 1. Cleanup Trial in the NTS Plutonium Valley. In: Transaction of the American Nuclear Society, Volume 43, pp. 56, Zacha, N. (Ed.), TANSAO 43, American Nuclear Society, Inc., La Grange Park, IL.

A cleanup and treatment (CAT) trial was conducted in Plutonium Valley at the Nevada Test Site (NTS) in 1981. The purpose was to develop a technique to reduce costs of decontaminating areas where radionuclides are deposited on or near soil surfaces. Two experimental plots, each 12 x 102 m and separated by 30 m, were laid out near "Site C", which is contaminated with relatively high levels of $^{239,\,240}$Pu and ^{241}Am. Vegetation and small-vertebrate surveys were done, after which the areas were devegetated with minimum disturbance. Soil was removed with a vacuum truck. Resultant contaminant concentrations on the plots and a very brief description of environmental damage on the plots are presented. The CAT trial demonstrated that this technique can remove minimum amounts of contaminated soil and reduce environmental impacts, even in a difficult natural terrain. (Authors) (CAW) *Keywords:* NAEG*, perturbations*, radionuclide inventory*, vegetation*, vertebrate*, methods*

170 DUNAWAY, P.B., and M.G. WHITE (Eds.). 1974. *The Dynamics of Plutonium in Desert Environments*, Nevada Applied

Ecology Group Progress Report as of January 1974. NVO-142, 369 pp.

A status report of the Nevada Applied Ecology Group research activities is given. The twenty-six articles included have been abstracted separately for the data base. Investigations on the soils of Pu-contaminated areas at the Nevada Test Site were reported with statistical analyses included. Other papers dealt with the Pu content of vegetation of contaminated areas; Pu metabolism in dairy cattle; grazing studies on Pu-contaminated areas, giving the radionuclide levels in Area 18 cattle; ecological studies of vertebrates; digestion of ingested Pu in chickens and subsequent transfer to eggs; the role of soil microorganisms in the movement of Pu; resuspension studies, including the use of NTS Data to predict air concentrations of Pu due to resuspension on the Eniwetok Atoll; distribution and inventory element activities on NTS and off-NTS; the Pu transport and dose estimation model; a description of the information support for the NAEG by the Oak Ridge Data Base and the Library Services at AEC Nevada Operations Office. (FMM) *Keywords:* NAEG*, radionuclide inventory*, vegetation*, vertebrate*, bird*, mammal*, radiation*, methods*

171 DUNAWAY, P.B., E.H. ESSINGTON, F.L. MILLER, Jr., J.A. ORCUTT, J.W. SHUGART, E.R. SOROM, E.M. ROMNEY, and T.P. O'FARRELL. 1986. Results of a Cleanup and Treatment Test at the Nevada Test Site: Evaluation of Vacuuming Radiological Contamination. EGG 10282-2192, S-352-TP.

We have conducted experiments to evaluate the effectiveness of removing contaminated soils from the Nevada Test site with a large, truck-mounted vacuum cleaner. Our results show that this method is effective, relatively easy, and safe for equipment operators. With four passes of the truck-mounted vacuum, 92% of the 241 Am (an the accompanying 239+240 Pu) was removed and resuspension rates were reduced by more than 99%. The ecological impact was, however, serious in terms of soil erosion and destruction of small animal habitats. (Authors) *Keywords:* NAEG*, perturbations*, radionuclide inventory*, mammal*, methods*

172 DURRELL, L.W., and L.M. SHIELDS. 1960. Fungi isolated in culture from soils of the Nevada Test Site. Mycologia 52:636-641.

Results of culturing 550 soil samples from the site of detonation of nuclear devices are reported, and the taxonomy and characteristics of the fungi isolated are described. Their resistance to uv radiation is also reported. By culture on Rose-Bengal agar containing streptomycin, 41 fungal taxa were isolated from surface and 3- to 6-in. samples of arid soils of the Nevada Test Site. Four taxa developed in from 40 to over 80% of the samples cultured: *Stemphylium ilicis, Fusarium* sp., *Phoma* sp., and *Penicillium oxalicum.* Certain of the species which produced black spores tended to predominate in cultures. Five of these species were also among the 14 isolated from Death Valley soils. The predominance of black-spored species in soils from the Nevada Test Site as well as from Death Valley suggests that in strongly insolated regions the melanin pigment affords a degree of protection. To determine relative resistance of fungal spores to uv light, cultures of a number of species were exposed to wavelength 2,573 R for different periods at 40 uw/cm^2/min. The time interval within which this exposure was 100% lethal is shown for seven representative species. Certain dark-spored species, as *S. ilicis*, *Stachybotrys atra,* and *Cladosporium herbarum*, survived prolonged exposures. *S. ilicis* spores were particularly resistant, germinating after 60 min in 95 to 100% of the exposed samples. Spores of *Aspergillus niger*, also black, were killed by two-min. exposure to uv light. The usual organic solvents did not extract the pigment from *S. ilicis* spores, while the spore pigment of *A. niger* dissolved readily in methyl alcohol. When thin layers of these spores attached to a quartz slide were checked by a spectrograph and electrospectrometer for determining light transmission, no light within the range of 2,000 to 20,000 A was seen to pass through *Stemphylium* spores. In contrast, the extracted pigment from *A. niger* spores showed a wide transmission band with a peak maximum at 12,000A. Spore or nuclear volume also may modify the effect of uv light. Possibly energy absorption is less rapid by large spores, as in *Stemphylium* sp., than by the small spores of *A. niger* with about 1/50 the volume. The dark spores of *Coccosporium*, however, with an approximate volume of 13,000 u^3 were killed in half the time required for *Stemphylium* with a spore volume of 8000 u^3. (Authors) *Keywords:* microbiota*, ecology/ecosystem*, radiation*, taxonomy*

173 DURRELL, L.W., and L.M. SHIELDS. 1961. Characteristics of soil algae relating to crust formation. Trans. Amer. Microscopical Soc. 80:73-79.

The algae *Microcoleus vaginatus* is enclosed in a colloidal sheath which binds particles of arid soil in a web-like matrix, consolidating a surface crust. The formation and accumulation of the sheath substance is favored by an alkaline reaction. Warping of the polygonal segments in drying results from greater shrinkage of the colloidal algal sheath material incorporated at the surface. The water holding capacity of the sheath contributes to the survival of algal cells and improves moisture relations in the felted crusts. In fluid, the trichomes of *Microcoleus vaginatus* grow beyond the enclosing sheath, assuming the appearance of *Phormidium* sp. The chemical composition of the sheath can be demonstrated by the action of hemicellulase, which digests it away, causing a rounding off of cross walls and resulting in fragmentation. Fragments revert to the filamentous habit when returned to culture. (Author) *Keywords:* soil property*, microbiota*, ecology/ecosystem*

174 EBERHARDT, L.L., and R.O. GILBERT. 1972. Statistical analysis of soil plutonium studies, Nevada Test Site. USAEC Report BN-WLB-217, 60 pp.

A summary is presented of the results of plutonium environmental studies that are part of the work of the Nevada Applied Ecology Group. Many of the field studies are currently not completed, but it seems desirable to produce a summary analysis of the statistical aspects. The report will be useful in planning further studies at the Test Site. Much of the work has been directed towards the problems of estimating the inventory of plutonium in soil. The only extensive set of data available thus far is from the GMX area. That data suggests that it is quite feasible to proceed with an inventory for GMX with the tools at hand. The report provides some preliminary results on the use of the FIDLER instrument in Area 13, but is thought not profitable to try to do too much interpretation of such comparisons without more crosschecking FIDLER counts against "wet" chemistry or similar analyses. Another section of the report provides a basis for decisions on the number of replicates for interlaboratory comparisons. It should be noted that this section serves for planning purposes -- once the study is completed, the results should be analyzed by other procedures (most likely an analysis of variance). (Authors) (FMM) *Keywords:* NAEG*, radionuclide inventory*

175 ECKEL, E.B. (Ed.). 1968. *Nevada Test Site*. The Geological Society of America, Inc., Memoir 110, 290 pp.

This book describes results of 12 years of geological research on the Nevada Test Site. The primary purpose of the studies was to aid and advise the USAEC in all phases of its testing of nuclear devices. An enormous amount of knowledge was gained about the complex geologic and hydrologic conditions that exist in and near NTS. The complex volcanic and sedimentary stratigraphy, structure, and geologic history of this part of the Basin and Range Province are described in detail. The deep fills in intermontane basins, and the groundwater in them, are known in three dimensions, and excellent geologic maps have been prepared and are described in the text. (TPO) *Keywords:* geology*, hydrology*

176 EDNEY, E.B., P.J. FRANCO, and J.F. MCBRAYER. 1976. Abundance and Distribution of Soil Microarthropods in Rock Valley, Nevada. US/IBP Desert Biome Res. Memo. 76-24. Utah State University, Logan, 17 pp.

Weekly observations throughout 1974 of the nature, density and distribution of soil arthropods in Rock Valley, Nevada, are reported, together with associated soil temperatures and moisture values. Density usually decreased at greater distances below the surface or away from the shrub base: however, density in the top 10 cm fell below that in the next 10 cm in June and September. In general, densities were highest in the winter months. Neither the size nor the species of shrubs affects the density of arthropods below them. Density is positively correlated with soil carbon concentration. Artificial watering confirmed the importance of soil moisture in controlling arthropod density, and changes in patterns of vertical distribution were associated with temperature changes. Increased soil salinity probably leads to a decrease in arthropod density. A more satisfactory model for calculating total numbers and biomass of arthropods present has been developed. Using these values and published measurements of oxygen consumption, calculations of total metabolism for various taxa and trophic levels of arthropods have been made. Approximately 0.2% of the total energy input involved in net primary productivity in the area was respired by detritivorous arthropods in 1974. (Authors) *Keywords:* IBP*, soil property*, invertebrate*, ecology/ecosystem*, methods*

177 EDNEY, E.B., J.F. MCBRAYER, P.J. FRANCO, and A.W. PHILLIPS. 1974. Distribution of soil arthropods in Rock Valley, Nevada. US/IBP Desert Biome Res. Memo. 74-32, 5 pp.

Work accomplished during 1973 was mostly preparative. During the period a satisfactory method of sampling desert soil arthropods was developed, using a modification of Newell's (1959) technique. Samples were taken in association with four species of shrubs, and the results for ten weeks during the summer are reported. Numbers were generally greatest near the soil surface at the bases of shrubs, and decreased with depth and distance from the shrub. Soil moistures and temperatures were obtained in association with the arthropod samples. Nearly all the taxa found have been identified at

least to family. Mites contributed the greatest numbers and diversity, and prostigmatids were the dominant group of mites.

(Authors) *Keywords:* IBP*, soil property*, invertebrate*, ecology/ecosystem*

178 **EDNEY, E.B., J.F. MCBRAYER, P.J. FRANCO, and A.W. PHILLIPS. 1975. Abundance and distribution of soil microarthropods in Rock Valley, Nevada. US/IBP Desert Biome Res. Memo. 75-29. Utah State University, Logan, 8 pp.**

Weekly observations from January through June 1974 of the nature, densities and distribution of soil arthropods in Rock Valley are reported. These show that densities decrease vertically and horizontally away from the base of the shrubs. There was a seasonal change of relative abundance with position; arthropods in the lower layer (20-30 cm) becoming relatively more abundant in June than in January. There was a pronounced increase in total numbers from a mean of 2.04 x 10^3 m^{-2} in January to 4.30 x 10^3 m^{-2} in March. Highest densities up to 10^4 m^{-2} occurred near the base of shrubs in March. No effect of size or species of shrub on arthropod density was observed. (Authors) *Keywords:* IBP*, invertebrate*, ecology/ecosystem*

179 **EG&G ENERGY MEASUREMENTS. 1984. An Analysis of the Small Mammal Data Collected by Brigham Young University at Sedan, 1962-63. Internal Report. Bechtel Environmental Sciences Library #550. Las Vegas, NV.**

In 1959, Brigham Young University initiated research at the NTS to study the effects of nuclear tests on native animals. The Sedan event of July, 1962, was a thermonuclear cratering experiment that provided biologists with their first opportunity to gather biological data before the detonation of a nuclear device. The study was designed to determine the kinds and population sizes of small mammals at various distances from Ground Zero before and after detonation and determine the extent of small mammal movements between disturbed and undisturbed areas. The survival of marked individuals before the shot and after indicates that all species experience drastic mortality. *Perognathus longimembris* the most abundant species on all plots had 325 marked individuals prior to the shot. Only 45 (13.6%) were recaptured three weeks after the event and only 9 of these individuals were captured in 1963. Other species showed similar effects. Both diversity and relative abundance of the mammalian fauna were greatly reduced following the event. (WKO) *Keywords:* perturbations*, mammal*, ecology/ecosystem*, radiation*

180 **EG&G ENERGY MEASUREMENTS. 1991. The Distribution and Abundance of Desert Tortoises on the Nevada Test Site. EGG 10617-2081. Santa Barbara Operations, Goleta, CA, pp. 41.**

This report presents the results of transect studies conducted from 1981-1986 to determine the distribution and abundance of desert tortoises (Gopherus agassizii) on the Nevada Test Site (NTS) and summarizes the current understanding of the distribution of this species on NTS. Seven hundred fifty-nine transects having a total length of 1,190.7 km were walked and 380 sign of tortoises were counted. The abundance of tortoises on NTS is low to very low relative to the other areas within this species' range. Tortoises appear to be more abundant on NTS on the bajadas and foothills of limestone and dolomite mountains than on mountains of volcanic origin. Sign of tortoises were found from 880 to 1,600 m and sign was more abundant at higher elevations (>1,200 m) than has been reported previously for Nevada. The scale of classification of vegetation associations available for NTS is too large to be useful for predicting tortoise abundance. Tortoises were found only in approximately the southern third of NTS. They probably do not occur in Yucca Flat or anywhere else north of the Control Point. A map of the northern boundary of the range of desert tortoises on NTS is presented and additional studies of the distribution and abundance of tortoises on NTS are recommended. (Authors) *Keywords:* geology*, desert tortoise*, ecology/ecosystem*

181 **EG&G ENERGY MEASUREMENTS. 1991. Yucca Mountain Biological Resources Monitoring Program, Annual Report FY89 & FY90. EGG 10617-2084. Santa Barbara Operations, Goleta, CA.**

This report discusses the progress of the biological resources monitoring program at Yucca Mountain. Study design of the ecological study plots are described. Data on vegetation cover, production and density are presented. Efforts to monitor impacts of Yucca Mountain site characterization activities on the desert tortoise are described. Preactivity surveys for endangered, threatened or sensitive species are described. Samples to assess baseline conditions for plants and animals were taken as part of the Yucca Mountain radiological monitoring program. (WKO) *Keywords*: YMSCO*, perturbations*, desert tortoise*, vegetation*, sensitive plants*, sensitive animals*, mammal*, ecology/ecosystem*

182 **EG&G ENERGY MEASUREMENTS. 1992. Yucca Mountain Biological Resources Monitoring Program, Annual Report FY91. EGG 10617-2127 UC-814. Santa Barbara Operations, Goleta, CA, pp. 68.**

This report discusses the progress of the biological resources monitoring program at Yucca Mountain. Results of studies conducted in 1991 are described. Data on vegetation cover, production and density are presented. Data from studies on small mammals, spotted bat, and invertebrate are presented. Efforts to monitor impacts of Yucca Mountain site characterization activities on the desert tortoise are described including studies of population dynamics, movements and habitat use, food habits, and relocation. Preactivity surveys for endangered, threatened or sensitive species are described. Reclamation trials and disturbed habitat studies were initiated. Samples to assess baseline conditions for plants and animals were taken as part of the Yucca Mountain radiological monitoring program which included conducting censuses for lagomorphs, game birds and predators. (WKO) *Keywords:* YMSCO*, perturbations*, desert tortoise*, sensitive plants*, perennial plants*, sensitive animals*, invertebrate*, bird*, mammal*, ecology/ecosystem*, revegetation*

183 EG&G ENERGY MEASUREMENTS. 1993. Baseline Vegetation Contamination at Safety Test Sites on the Nevada Test Site and Tonopah Test Range. EG&G Energy Measurements, Environmental Sciences Department, Las Vegas, NV.

EG&G/EM Environmental Sciences Department initiated a study in 1990 to determine the characteristics of vegetation contamination of sites at the NTS and TTR. This information will aid in the development of strategies for vegetation removal or decontamination. Specific objectives of the study were as follows: (1) to determine if seasonal variation in contamination existed for dominant species at the NTS and TTR; (2) to determine the level of vegetation contamination across differing zones of soil contamination (i.e. ground zero and outward); (3) to determine if differences in amounts of contamination varied among species within each site; and (4) the interactions of each of the above characteristics. A secondary objective was to compare vegetation contamination results with that of the NAEG to determine if changes in the levels of contamination have occurred over time. (Authors) *Keywords*: perennial plants*, radiation*

184 EG&G ENERGY MEASUREMENTS. 1993. Yucca Mountain Biological Resources Monitoring Program, Annual Report FY92. EGG 10617-2195 UC-814. Santa Barbara Operations, Goleta, CA, pp. 77.

This report discusses the progress of the biological resources monitoring program at Yucca Mountain. Results of studies conducted in 1992 are described. Data on vegetation cover, production and density are presented. Data from continuing studies on small mammals, spotted bat, and invertebrates are presented. New efforts to monitor reptiles and birds were initiated. Efforts to evaluate impacts of Yucca Mountain site characterization activities on the desert tortoise are described including studies of population monitoring, movements and habitat use, food habits, health monitoring, raven monitoring and relocation. Preactivity surveys for endangered, threatened or sensitive species are described. Reclamation trials and disturbed habitat studies continued and additional trials were established. Samples to assess baseline conditions for plants and animals were taken as part of the Yucca Mountain radiological monitoring program which included conducting censuses for lagomorphs, game birds and predators. (WKO) *Keywords:* YMSCO*, perturbations*, desert tortoise*, sensitive plants*, sensitive animals*, perennial plants*, invertebrate*, bird*, reptile*, mammal*, ecology/ecosystem*

185 EG&G ENERGY MEASUREMENTS. 1994. Yucca Mountain Biological Resources Monitoring Program, Progress Report October 1992-December 1993. EGG 11265-1073 UC-708. Nevada Program, Las Vegas, NV, 69 pp.

This report discusses the progress of the biological resources monitoring program at Yucca Mountain. Results of studies conducted from October 1992 through December 1993 are described. Data on vegetation cover, production and density are presented. Data from continuing studies on small mammals and reptiles are presented. Efforts to evaluate impacts of Yucca Mountain site characterization activities on the desert tortoise continued including studies of population monitoring, movements and habitat use, food habits, health monitoring, raven monitoring and relocation. New efforts on tortoise reproduction and survival were initiated. Preactivity surveys for endangered, threatened or sensitive species are described. Reclamation trials and disturbed habitat studies continued and additional trials on topsoil stockpiles were established. Also implementation of reclamation was initiated for disturbed sites no longer needed for site characterization. Samples to assess baseline conditions for plants and animals (including cattle) were taken as part of the Yucca Mountain radiological monitoring program which included conducting censuses for lagomorphs, game birds and

predators. (WKO) *Keywords:* YMSCO*, perturbations*, desert tortoise*, perennial plants*, bird*, mammal*, ecology/ecosystem*, revegetation*

186 EG&G ENERGY MEASUREMENTS. 1995. Yucca Mountain Biological Resources Monitoring Program, Progress Report January 1994-December 1994. EGG 11265-1136 UC-808. Nevada Program, Las Vegas, NV, 79 pp.

This report discusses the progress of the biological resources monitoring program at Yucca Mountain. Results of studies conducted from January 1994 through December 1994 are described. Data on vegetation cover, production and density are presented although production and density data were only sampled at a reduced number of study plots. Efforts to map the vegetation at Yucca Mountain were initiated. Data from continuing studies on small mammals and reptiles are presented. Efforts to evaluate impacts of Yucca Mountain site characterization activities on the desert tortoise continued including studies of population monitoring, movements and habitat use, food habits, health monitoring, raven monitoring and relocation. Efforts on tortoise reproduction and survival continued. A new study on the effect of ground motion from blasting on desert tortoise and their burrows was initiated. Preactivity surveys for endangered, threatened or sensitive species are described. Reclamation trials continued and additional trials on topsoil stockpiles were established. Studies on succession of disturbed habitats were concluded and a topical report was prepared. Implementation of reclamation was continued for disturbed sites no longer needed for site characterization. Sampling to assess baseline radiological conditions for plants and animals was discontinued. (WKO) *Keywords:* YMSCO*, perturbations*, desert tortoise*, perennial plants*, bird*, mammal*, reptile*, ecology/ecosystem*, revegetation*

187 EL-GHONEMY, A.A., A. WALLACE, and E.M. ROMNEY. 1978. Nutrient Concentrations in the Natural Vegetation of the Mojave Desert. Soil Science. Vol. 126, No. 4:219-229.

The mineral composition of perennial plant species form widely separated sites in the Mojave Desert varied among sites, but variation between species was more pronounced. According to the nutritional status, species have been classified into different categories each of which includes species characteristically rich or poor in a given element. The close relationships between the nutritional status of these species and their sociological relations, as reflected by the principal component analyses, are evaluated. The frequency of correlation between the concentration of the different element pairs across the different species studied has been evaluated and discussed. Stress has been focused on Ca-Zn relations, with an 80 percent frequency of positive correlation. The causal factor or factors behind this high percentage of positive correlation frequency have been suggested. Linear correlation coefficients between plant composition and soil variables were also obtained. (Authors) *Keywords:* soil property*, perennial plants*, nutrition/diet*

188 EL-GHONEMY, A.A., A. WALLACE, and E.M. ROMNEY. 1980. Frequency Distribution of Numbers of Perennial Shrubs in the Northern Mojave Desert. Great Basin Naturalist Memoirs No. 4:34-38.

Frequency distribution according to plant size as measured by dimensional analysis on different mathematical bases were determined for 10 common perennial plant species from Rock Valley in the northern Mojave Desert in Nevada. A total of 4282 individual plants was measured. The data provide information concerning the stability and prosperity of the natural vegetation as judged by the relative proportions of individuals in the size-class spectrum, as well as show graphically the relative abundance of the different species in the study area. On the species level, the populations were close to normally distributed on the $\log_e$ basis, but with remarkably negative skewness due to better segregation of the small-sized individuals into many segmental units. On the arithmetic basis, three categories of frequency pattern were recognized, but all with marked positive skewness due to better segregation of large-sized individuals into many segmental units. The feature common to all species studied is the preponderance of young individuals, which in many cases could have an abundance many times that of large individuals. The natural vegetation in Rock Valley, therefore, represents a reasonably active stage. (Authors) *Keywords:* IBP*, perennial plants*, ecology/ecosystem*, methods*

189 EL-GHONEMY, A.A., A. WALLACE, and E.M. ROMNEY. 1980. Multivariate Analysis of the Vegetation in a Two-Desert Interface. Great Basin Naturalist Memoirs No. 4:42-58.

This report further describes the distribution and ecological characteristics of the natural vegetation at the Mojave Desert-Great Basin Desert interface. The region studied is one of extraordinary biological interest because of its geographic location straddling the boundaries of two large deserts of the western United States, and because of the kind and manner of its past land use (atmospheric and underground testing of nuclear devices). The present analysis determines the magnitude of variations in the phytosociological structure in this region and evaluates some relationships between its vegetation and environment. Vegetation and soils were sampled in 66 stands representing many possible physiographic variations. Relative density and relative coverage were determined for each perennial species and summed to provide an estimate of its importance value (I.V.). Importance values were used to ordinate stands to provide a synthesis of the phytosociological data and to portray the compositional relationships of species. The results of this study indicate that the area is dominated by several interrelated vegetational groupings. Correlations between the vegetational groups and the different environmental variables indicate that the distributional pattern of the vegetation is controlled largely by soil physical properties, salinity, and fertility levels. (Authors) *Keywords:* perennial plants*, ecology/ecosystem*

190 **EL-GHONEMY, A.A., A. WALLACE, and E.M. ROMNEY. 1980. A Phytosociological Study of a Small Desert Area in Rock Valley, Nevada. Great Basin Naturalist Memoirs No. 4:59-72.**

The aim of this study was to gain more understanding of the compositional structure of vegetation in the US/IBP Desert Biome validation site located in Rock Valley, Nevada. The vegetation data collected from 85 stands, randomly distributed to cover all physiographic variations in the study site, permitted categorization of the vegetation units either by coordinates or by class membership. The vegetational groupings so identified were then used for constructing a more reliable vegetation map for the Rock Valley validation site. (Authors) *Keywords:* IBP*, perennial plants*, ecology/ecosystem*

191 **EL-GHONEMY, A.A., A. WALLACE, and E.M. ROMNEY. 1980. Socioecological and Soil-Plant Studies of the Natural Vegetation in the Northern Mojave Desert. Great Basin Naturalist Memoirs No. 4:73-88.**

The purpose of this study is to further describe the distribution, habitats, and ecological characteristics of the natural vegetation in the northern sector of the northern Mojave Desert. Sixty-six stands were classified on the basis of shared leading dominant species. Each of these groupings is well defined and represents a sociologically distinct entity quite recognizable in the field. The relationships between each vegetational grouping and several environmental variables were statistically analyzed. Significant differences were found among plant groupings with respect to soil moisture tension, absolute and relative amounts of exchangeable Na, exchangeable K, cation exchange capacity, and elevation. The analysis of the relationship between the phytosociological behavior of the major leading dominant species and the environmental variables shows that some of the simple, or multiple, linear correlations obtained with regard to *Larrea tridentata* (Sesse & Moe. ex DC.) Cov. were highly significant. *Atriplex confertifolia* (Torn & Frem.) S. Wats. and *Atriplex canescens* (Pursh) Nutt. showed the highest number of significant correlations obtained. Diversity varies from one vegetational grouping to the other as well as between stands of the same grouping. The grouping of *L. tridentata* has proved to be the most widespread, diversified, and, consequently, the most stable vegetation cover in the study area; it, therefore, represents a climax community. The vegetational grouping dominated by *A. confertifolia*, on the other hand, appears not to be a climax community. (Authors) *Keywords:* soil property*, perennial plants*

192 **ENGEL, R.E., and R.A. BRECHBILL. 1967. Radiation surveillance in wildlife. CONF-670724-1, 5 pp. From Conference of Western Association of Fish and Game Commissioners, Honolulu, HI.**

A report on the wildlife surveillance activities in the Nevada Test Site environs is presented. The purpose of the study is fourfold, and includes: maintenance of veterinary public relations with the off-site population, investigation of alleged damage to domestic animals from AEC activities, determination of the tissue concentration of fission products in samples obtained from bovines on off-site ranches, University of Nevada Experimental Station and the Nevada Test Site, and development and conduction of wildlife studies on and near the Nevada Test Site to assess radionuclide content of edible wildlife species. In connection with this fourfold study, a study of the fission product accumulation of the Nevada Test Site mule deer was initiated. Background levels of radioisotopes in the desert bighorn sheep ranging in the Nevada Test Site were also determined. Beginning in July 1965 a survey of the ^{90}Sr content of the hock joints in wildlife ruminants was conducted under the assumption that these samples would serve as biological dosimeters from which fallout could be determined. A cooperative mule deer food habit analysis study is currently being conducted with various agencies in the area. Hock joints and thyroids are analyzed in this study,the former for ^{90}Sr, the latter for ^{131}I. Here again, the thyroid was used as a biological dosimeter for ^{131}I in that portion of the state. The migration routes of the mourning dove are the object of intense investigation in the test site area. Trap mortalities are utilized to assess radioisotope content in these birds. (ERB) *Keywords:* bird*, mammal*, radiation*

193 **ENSMINGER, J.T., C.S. FORE, and N.S. DAILEY (Eds). 1978. Environmental Aspects of the Transuranics - A Selected, Annotated Bibliography - Vol. 9. NVO/AEIC-78/1, Nevada Applied Ecology Group, Nevada Operations Office, Oak Ridge National Laboratory, 277 pp.**

This ninth published bibliography of 589 references is compiled from the Nevada Applied Ecology Information Center's Data Base on the Environmental Aspects of the Transuranics. The data base was built to provide information. support to the Nevada Applied Ecology Group (NAEG) of DOE's Nevada Operations Office. The general scope covers environmental aspects of uranium and the transuranic elements, with emphasis on plutonium. This annotated bibliography highlights literature on plutonium 238 and 239 and americium 241 in the critical organs of man and animals. Studies on the migration of plutonium and the transplutonics through the environment are also emphasized. Supporting information on ecology of the Nevada Test Site and reviews and summarizing literature on other radionuclides have been included at the request of the NAEG. The references are arranged by subject category with leading authors appearing alphabetically within each category. Indexes are provided for author(s), geographic location, keywords, taxonomic name, title, and publication description. (Authors) *Keywords*: NAEG*, bibliography*, radionuclide inventory*, mammal*, ecology/ecosystem*, radiation*

194 ENSMINGER, J.T., F.M. MARTIN, and C.S. FORE (Eds). 1977. Environmental Aspects of the Transuranics - A Selected, Annotated Bibliography - Vol. 8. NVO/AEIC-77-1, Nevada Applied Ecology Group, Nevada Operations Office, Oak Ridge National Laboratory, 198 pp.

This eighth published bibliography of 427 references is compiled from the Nevada Applied Ecology Information Center's Data Base on the Environmental Aspects of the Transuranics. The data base was built to provide information support to the Nevada Applied Ecology Group (NAEG) of ERDA's Nevada Operations Office. The general scope covers environmental aspects of uranium and the transuranic elements, with emphasis on plutonium. This bibliography highlights literature on plutonium 238 and 239 and americium in the critical organs of man and animals. Supporting information on ecology of the Nevada Test Site and reviews and summarizing literature on other radionuclides have been included at the request of the NAEG. The references are arranged by subject category with leading authors appearing alphabetically in each category. Indexes are provided for author(s), geographic location, keyword(s), taxon, title, and publication description. (Authors) *Keywords:* NAEG*, bibliography*, radionuclide inventory*, mammal*, ecology/ecosystem*, radiation*

195 ENVIRONMENTAL SCIENCE ASSOCIATES. 1990. 1989 wildlife studies at Yucca Mountain, Nye County, Nevada. NWPO-EV-001-89, Nevada Nuclear Waste Project Office, Department of Energy, Carson City, NV, 19 pp.

The primary objectives of the field investigations were to assess the late summer/early autumn conditions in the Focused Baseline Study Area (FBSA), to make observations useful in developing reclamation strategies and impact models, to compare data with those developed by the Department of Energy (DOE), and to obtain information that can be used for monitoring DOE activities during Site Characterization. The studies were being conducted in conjunction with a portion of the work program presented in the Nevada Environmental Studies Plan, for the Nevada Nuclear Waste Project Office. The investigations entail the collection of primary data on the vegetation, wildlife, and soils and landforms of the study area. 9 refs., 4 tabs. (Authors) *Keywords:* YMSCO*, geology*, soil property*, vegetation*, vertebrate*, ecology/ecosystem*

196 ESQUE, T.C., R.B. BURY, and P.A. MEDICA. 1990. Distribution, habitat and habits of the desert tortoise (*Gopherus agassizii*) in the eastern Mojave Desert. Presented at: 1990 American Society of Ichthyologists and Herpetologists (ASIH) Conference, Charleston, SC, 16 Jun 1990. CONF-9006200-1, Reynolds Electrical & Engineering Co., Inc., Mercury, NV.

The desert tortoise is widely distributed across most of southern Nevada below 1,500 meters elevation and then ranges northeast into the Arizona Strip and southwestern Utah. There are several large populations, but also many isolated groups of desert tortoises due to the rugged topography and, possibly, unsuitable soils. We suggest that the greatest threats to tortoises in the eastern Mojave Desert are with peripheral populations. Tortoises in the eastern Mojave Desert occupy a wide variety of habitats from flats and bajadas in lower elevation to rocky slopes bordering on blackbrush and juniper woodland. In winter they use shallow burrows near Las Vegas but frequent deep caves in the northeast edge of their range. Tortoises in all areas may occur in steep, rocky habitats. Climatic extremes are frequent in this region and rainfall can be spotty due to several major mountain ranges that cause rain shadows. Forage is highly variable and this species can be an opportunistic herbivore. 11 refs., 13 figs. (Authors) *Keywords:* climate*, geology*, desert tortoise*, ecology/ecosystem*, nutrition/diet*

197 ESSINGTON, E.H., H. NISHITA, and A.J. STEEN. 1965. Release and movement of radionuclides in soils contaminated with fallout material from an underground thermonuclear detonation. Health Physics 11:689-698.

Fallout material from an underground thermonuclear detonation was analyzed to determine the presence of several longer lived radionuclides. The following radionuclides were identified: Zr-95: Nb-95, Ru-103:Ph-106, I-131, Cs-137:Ba-137, Ba-140:La-140, Ce-141, Ce-144:Pr-144, Sc-46, Mn-54, Y-88, Ph102, W-181, W-185 and W-188: Re-188. Radiotungsten contributed the major fraction of the total activity. In suspension studies, chelating agents as compared to water generally increased the amount of soluble radionuclides but the effect was small. The effect of water and a chelating agent on the movement of radionuclides in soil columns were also studied. (Authors) *Keywords:* NAEG*, radionuclide inventory*

198 **ESSINGTON, E.H., R.O. GILBERT, D.L. WIREMAN, D.N. BRADY, and E.B. FOWLER. 1977. Plutonium, Americium, and Uranium in Blow-Sand Mounds of Safety-Shot Sites at the Nevada Test Site and the Tonopah Test Range. In: *Transuranics in Desert Ecosystems.* White, M.G., and P.B. Dunaway (Eds.). NVO-181, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 81-146.**

Blow-sand mounds or miniature sand dunes and mounds created by burrowing activities of animals were investigated by the Nevada Applied Ecology Group (NAEG) to determine the influence of mounds on plutonium, americium, and uranium distributions and inventories in areas of the Nevada Test Site and Tonopah Test Range. Those radioactive elements were added to the environment as a result of safety experiments of nuclear devices. Two studies were conducted. The first was to estimate the vertical distribution of americium in the blow-sand mounds and in the desert pavement surrounding the mounds. The second was to estimate the amount or concentration of the radioactive materials accumulated in the mound relative to the desert pavement. Five mound types were identified in which plutonium, americium, and uranium concentrations were measured: Grass, Shrub, Complex, Animal, and Diffuse. The mound top (that portion above the surrounding land surface datum), the mound bottom (that portion below the mound to a depth of 5 cm below the surrounding land surface datum), and soil from the immediate area surrounding the mound were compared separately to determine if the radioactive elements had concentrated in the mounds. Results of the studies indicate that the mounds exhibit higher concentrations of plutonium, americium, and uranium than the immediate surrounding soil. The type of mound does not appear to have influenced the amount of the radioactive material found in the mound except for the Animal mounds where the burrowing activities appear to have obliterated distribution patterns. (Authors) *Keywords:* NAEG*, radionuclide inventory*, vegetation*, vertebrate*

199 **FARNSWORTH, R.B., E.M. ROMNEY, and A. WALLACE. 1978. Nitrogen fixation by microfloral-higher plant associations in arid to semiarid environments, pp. 17-19. In: West, N.E., and J. Skujins (Eds.), *Nitrogen in Desert Ecosystems.* US/IBP Synthesis Series 9. Dowden, Hutchinson & Ross, Inc., Stroudsburg, PA.**

This brief chapter explores the possible types of nitrogen fixation that occurs in desert soils. They include symbiotic fixation in legumes and non-legumes and parasymbiotic fixation due to rhizospheral, mycorrhizal, and phyllosperal associations. Although many interesting qualitative leads have developed to implicate many possible types of higher plant-microbial and fungal associations in nitrogen fixation within ecosystems of arid to semiarid environments, much quantitative verification of their importance remains to be done. Hopefully, this review will contribute to the development of needed new research. (Authors) *Keywords:* IBP*, soil property*, microbiota*, vegetation*, nutrition/diet*

200 **FAUST, R.A., F.M. MARTIN, C.T. SANDERS, and S.S. TALMAGE (Eds.). 1975. Environmental Aspects of the Transuranics - A Selected, Annotated Bibliography. NVO-AEIC-75-1, Nevada Applied Ecology Group Nevada Operations Office, Oak Ridge National Laboratory, 219 pp.**

This fifth published bibliography of 594 references is from the computer file built to provide information support to the Nevada Applied Ecology Group (NAEG) of ERDA's Nevada Operations Office. The general scope is environmental aspects of uranium and the transuranic elements with a preponderance of material on plutonium. In addition, supporting materials involving basic ecology or general reviews on other nuclides are entered at the request of the NAEG. Tables containing significant numeric data are referred to in the comment field. The references are arranged by subject category with first authors arranged alphabetically within the category. Indexes are given for author, keywords, geographic location, permuted title, taxons, and publication description. (Authors) *Keywords:* NAEG*, bibliography*, radionuclide inventory*, radiation*, ecology/ecosystem*

201 **FERGUSON, W.E. 1967. Male sphaeropthalmine mutillid wasps of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 8(4), 26 pp.**

As a part of the ecological studies of the Nevada Test Site, taxonomy and distribution of nocturnal mutillid wasps was detailed. It was shown that "ground zero" of nuclear detonations are reoccupied by mutillids within a few years of an explosion because of the attractive nesting sites for hymenoptera hosts of the parasitic mutillids. Genetic abnormalities for the wasps were not noted, possibly because abnormal genetic traits would prove fatal in the harsh desert environment.

Specimens were collected in can pittraps and light-traps. A description and discussion of taxonomic types is presented, including new species. (BBM) *Keywords:* invertebrate*, radiation*, taxonomy*

202 **FLAKE, L.D., and C.D. JORGENSEN. 1969. Invasion of a "trapped out" southern Nevada habitat by *Perognathus longimembris.* Great Basin Naturalist Memoirs 29:143-149.**

A 6.3 ha grid was established at the United States Atomic Energy Commission's Nevada Test Site and the small mammals trapped-out during the summers of 1964 and 1965 to study invasion by *Perognathus longimembris* Coues. Age analyses were made to determine the relationship between age and invasion. The mean age of invading animals was lowest in mid and late summer, but varied widely with reproductive success. There was no statistically significant difference in mean age between male and female invaders. Ratios of male to female invaders varied directly with that of the natural population. Invasion rates varied widely and were mainly influenced by population density outside the grid. (Authors) *Keywords:* mammal*, ecology/ecosystem*

203 **FORE, C.S., R.F. CARRIER, and E.W. DANIEL. 1983. Nevada Applied Ecology Group Publications. NVO/AEIC-264, Nevada Applied Ecology Information Center, Oak Ridge National Laboratory, Oak Ridge, TN, 352 pp.**

Since January 1972, the Nevada Applied Ecology Information Center (NAEIC) of the Information Center Complex, Unframed Division, Oak Ridge National Laboratory, had provided technical information support to the Nevada Applied Ecology Group (NAEG) relevant to the behavior of specific radionuclides in the environment. This bibliography of 808 references represents a summary of the biomedical and environmental studies conducted by the NAEG and its contractors. The bibliography focuses on research sponsored by the NAEG and also includes related publications by the NAEG contractors, which reflect the broad interests of the NAEG programs. The references are organized by subject areas of immediate interest to the NAEG (e.g., soil, vegetation, animal, microorganism, resuspension, and meteorological studies and environmental surveillance, statistics, modeling, and support functions). Indexes are provided for: (1) author, (2) title, and (3) publication description. All references contained in this publication are stored in a computerized form that is readily available upon request to NAEG and its contractors. (Authors) *Keywords:* NAEG*, bibliography*, climate*, radionuclide inventory*, vegetation*, vertebrate*, ecology/ecosystem*, radiation*, methods*

204 **FORE, C.S., R.A. FAUST, and R.H. BREWSTER. 1982. Cleanup and Treatment of Radioactively Contaminated Land Including Areas Near Nuclear Facilities (A Selected Bibliography). NVO/AEIC-243. Information Division, Oak Ridge National Laboratory, Oak Ridge, TN, 235 pp.**

Since January 1972, the Nevada Applied Ecology Information Center (NAEIC) of the Hazardous Materials Information Center, Information Center Complex, Information Division, Oak Ridge National Laboratory, has provided technical information support to the Nevada Applied Ecology Group (NAEG) relevant to the movement of plutonium and the transplutonics in the environment. In October 1977, NAEG began focusing its efforts on the cleanup and treatment of radioactively contaminated land. This annotated bibliography of 337 references summarizes the literature published on this subject area. Specifically, this bibliography focuses on literature concerned with the methods of cleanup and treatment being applied chemical, physical, or vegetative stabilization; the types of equipment being used; and the influence of climatic conditions on the method selected for use. The emphasis in such literature is placed on hazardous site cleanup efforts that have been completed as well as those that are in progress and are being planned. Appendix A includes 135 additional references to literature identified by NAEIC but not included in the bibliography because of time and funding constraints. Appendix B consists of a table that identifies the cleanup and treatment research conducted at specific sites. All of the information included in this bibliography is stored in a computerized form that is readily available upon request to NAEG and its contractors. (Authors) *Keywords:* NAEG*, bibliography*, perturbations*, vegetation*, revegetation*, methods*

205 **FORE, C.S., F.M. MARTIN, and R.A. FAUST (Eds.). 1976. Environmental Aspects of the Transuranics (A Selected, Annotated Bibliography). ORNL-EIS-91-V.7, NVO/AEIC-76/1, Nevada Applied Ecology Group Nevada Operations Office, Oak Ridge National Laboratory, 198 pp.**

This seventh published bibliography of 500 references is compiled from the Data Base on the Environmental Aspects of the Transuranics built to provide information support to the Nevada Applied Ecology Group (NAEG) of ERDA's Nevada Operations Office. The general scope is environmental aspects of uranium and the transuranic elements, with emphasis on plutonium. Laboratory and field studies dealing with the effects of plutonium 239 on animals are highlighted in this bibliography. Supporting information on ecology of the Nevada Test Site and reviews on the effects of other radionuclides upon man and his environment has been included at the request of the NAEG. The references are arranged by subject category with first authors appearing alphabetically in each category. Indexes are given for author, geographic location, keywords, taxons, permuted title and publication description. (Authors) *Keywords:* NAEG*, bibliography*, vertebrate*, radiation*, ecology*/ecosystem*

206 FOUNTAIN, E.L., and M.S. SEAL. 1967. Strontium-90 in the bones of big game in the Western United States. Health Physics 13:1205-1209.

Bone samples from big game killed during hunting seasons were obtained for determination of the ^{90}Sr present. The observed content of ^{90}Sr rose slightly in 1959, decreased in 1961, and rose again in late 1964 and early 1965. Annual rainfall and the dietary habits of the observed animals appeared to influence the ^{90}Sr content more than the proximity to the Nevada Test Site. (Authors) (UK) *Keywords:* mammal*, nutrition/diet*, radiation*

207 FOWLER, E.B., R.O. GILBERT, and E.H. ESSINGTON. 1976. Sampling of soils for radioactivity: philosophy, experience, and results. In: (Engelmann, R.J., and G.A. Sehmel, Coordinators) *Atmosphere-Surface Exchange of Particulate and Gaseous Pollutants* [1974], Proceedings of the Symposium held at Richland, Washington, September 1974 (CONF-740921), pp. 709-726.

This paper presents information on the philosophy and development of methods used in the Nevada Applied Ecology Group's program to define plutonium levels in soils. The program required interaction of experts in sampling, sample preparation, sample analyses, and data interpretation for successful implementation. (TPO) *Keywords:* NAEG*, radionuclide inventory*, methods*

208 FRANCIS, C.W., S.S. TALMAGE, and B.B. MCMULLIN. 1975. Radionuclide Movement in Soils and Uptake by Plants: A Selected, Annotated Bibliography. ORNL-EIS-75-77, ESD-732, Oak Ridge National Laboratory, Oak Ridge, TN.

This selected annotated bibliography was originally assembled as an information retrieval data base for the purpose of writing a comprehensive literature review by C.W. Francis on the movement of radionuclides in soil and uptake by plants. The data base was started when it became apparent that only through such a retrieval system could the voluminous amount of literature be critically surveyed. The data base is a result of literature searches from 1948 to 1975. It contains information on how various chemical, physical, and biological factors influence the movement of radionuclides in soils and uptake in plants. As a result of public concern about radioactive fallout prior to the moratorium on nuclear testing in the atmosphere, much of the data is related to the major fission products in radioactive fallout, strontium-90 and cesium-137. A concentrated effort was made to select the literature that dealt with processes affecting the movement and biological availability of radionuclides. Consequently literature in which the major purpose was to report concentrations of radionuclides in soils and plants, such as monitoring type reports, was not included. The data base includes references to nearly all fission products, a large number of biologically important activation products and various naturally occurring radioactive nuclides such as uranium and thorium. The Russian literature has been carefully surveyed, and the data base probably represents the most complete bibliography on research efforts in the USSR related to radionuclide transport in soil-plant systems. (Authors) *Keywords*: bibliography*, vegetation*, ecology/ecosystem*, nutrition/diet*, radiation*

209 FRANCO, P.J., E.B. EDNEY, and J.F. MCBRAYER. 1979. The Distribution and Abundance of Soil Arthropods in the Northern Mojave Desert. Journal of Arid Environments 2:137-149.

Arthropods were extracted from soil samples taken from around four perennial plant species in Rock Valley, Nevada, from January to December 1974. The pattern of distribution of the arthropods about the shrubs is described and a model has been constructed to estimate population densities and biomass. Total arthropod densities ranged from 1,600 per m^2 in July to 12,400 per m^2 in December. Total biomass was also lowest in July, 8.7 mg/m^2, and reached 37.2 mg/m^2 in May. The majority of animals collected belonged to the Acari, and of these the Cryptostigmata and the Prostigmatid families, Nanorchestidae and Tydeidae, were most abundant. Seasonal variations in the distribution patterns are discussed. (Authors) *Keywords*: invertebrate*, ecology/ecosystem*

210 FRECKMAN, D.W. 1978. Ecology of anhydrobiotic nematodes, pp., 345-57. In: Crowe, J.H., and H.S. Clegg (Eds.), Dry

Biological Systems. Academic Press, New York.

The author discusses dehydration of anhydrobiotic nematodes. She discusses morphological studies done by herself and others and the microenvironmental factors which induce anydrobiosis. The author presents data collected at Rock Valley in 1974 relating nematode oxygen consumption, soil temperature, and moisture. She used and discusses the sucrose technique to determine the duration of the nematode anhydrobiotic state. (CAW) *Keywords:* soil property*, invertebrate*, ecology/ecosystem*, physiology*, methods*

211 **FRECKMAN, D.W. 1979. Cryptobiosis and its effect on metabolism and production estimates of desert nematodes. US/IBP Desert Biome Res. Memo. 77-19. Utah State University, Logan, 9 pp.**

A technique was developed for extraction of nematodes in the anhydrobiotic state from dry desert soils. Morphologically, the anhydrobiotic nematodes were coiled and shrunken in size. Anhydrobiosis, as represented by the coiled form of nematodes from desert soils, was not confined to any particular life stage or trophic group. Studies on the soil moisture levels necessary to rehydrate anhydrobiotic nematodes and return them to metabolic activity indicate that metabolic activity resumes at a soil moisture level of about 2.7% . A more precise model for determining total numbers and biomass of the nematode community present in desert soils was developed. The annual mean number of nematodes was $.12 \times 10^6/m^2$ and the biomass was $.039\ g/m^2$. The effect of a lowered, nondetectable metabolism was considered in all calculations of oxygen consumption. Cumulative annual metabolism, production, assimilation and consumption figures are presented for nematode trophic groups at Rock Valley, Nevada in 1974. (Author) *Keywords:* IBP*, soil property*, invertebrate*, ecology/ecosystem*, physiology*, methods*

212 **FRECKMAN, D.W., and R. MANKAU. 1976. Biology of nematodes in desert ecosystems. US/IBP Desert Biome Res. Memo. 76-25. Utah State University, Logan, 5 pp.**

Estimates of nematode oxygen consumption at Rock Valley have been completed for 1974. These estimates do not include the effect of cryptobiotic periods during which there is a lower metabolic rate on nematode oxygen consumption. Nematode numbers and biomass for each trophic group were completed for the Rock Valley site. Microbial feeders were the most numerous, 2,648/500 cm^3 soil, of all trophic groups at the 0-10 cm depth at the base of the plant, followed by omnivore predators, fungal feeders and plant parasites. An average of all trophic groups showed a significant decline in numbers of nematodes with increasing depth and distance from plant. Of the four plant species, the largest numbers and biomass of nematodes were associated with *Lycium andersonii* and *Larrea tridentata*, including the most numerous populations of plant parasites. The density of omnivore-predators was not significantly different from plant to plant whereas the density of microbivores and fungivores was slightly higher under *Ambrosia* and *Krameria*, respectively. The annual mean number of nematodes was 422,590/m^2; annual respiration was 1,590 ml $O_2 \cdot m^{-2} \cdot yr^{-1}$ (uncorrected for any cryptobiotic periods). (Authors) *Keywords:* IBP*, perennial plants*, invertebrate*, ecology/ecosystem*, nutrition/diet*

213 **FRECKMAN, D.W., and R. MANKAU. 1977. Nematodes and microflora in the root rhizosphere of four desert shrubs, pp. 423-32. In: Harley, J.L., and R. Russell (Eds.), The Soil-Root Interface. Academic Press, London.**

The relationship of nematodes, fungi, bacteria and actinomycetes to root systems was studied in soils of the Mojave desert, Rock Valley, Nevada, USA. Parameters examined included spatial and seasonal distribution of organisms and roots and the abiotic factors of soil temperature and moisture. Soil samples were collected weekly from four perennial plant species, *Larrea tridentata, Lycium andersonii, Krameria parvifolia* and *Ambrosia dumosa*, which represented 75% of the dominant vegetation at Rock Valley. One shrub of each species was examined weekly. Soil samples were taken at 3 depths and 3 distances from the shrubs. An identical set of samples was collected to determine root biomass. Nematodes were extracted from soil by a modified sugar flotation technique developed for use in desert soils. The nematodes were counted, identified and placed in the following groups: (1) microbivores - mainly Caphalobidae, (2) omnivore-predators - Dorylaimina, excluding *Xiphinema, Longidorus* and *Trichodorus*, (3) fungivores - *Aphelenchus avenae, Aphelenchoides* sp. and *Ditylenchus* sp., (4) phytophages - mainly Tylenchorhynchinae. Damaged or unidentifiable nematodes comprised a fifth group. Roots were separated into two groups. Small roots (0.5 - 2 mm) were separated by screening and flotation in $MgSO_4$ solution from 0.3 liter of soil and larger roots (2 mm) by manual separation from 1.5 liter soil. Dilution plate counts were made to quantify and differentiate the fungal, bacterial and actinomycete populations of the soil samples. The spatial distribution of all nematode trophic groups was positively correlated with root biomass. Nematode density, fungal and bacterial populations decreased with depth and distance from the plant. The abundance of microflora in decreasing order was actinomycetes, bacteria and fungi. Actinomycetes were not influenced by depth or distance from the shrubs. The distribution of nematodes was closely related to food sources. Microbivores were the most numerous trophic nematode group at all depths and distances followed by omnivore-predators, fungivores and plant feeders. Plant feeders represented only 14-17% of the total population and were most numerous in association with *Lycium* and *Larrea*. The density and biomass of trophic groups of nematodes other than phytophages was intimately associated with the root rhizosphere in desert soils where food sources were available for even the detritus-based nematode trophic groups. (Authors) *Keywords:* IBP*, soil property*, perennial plants*, invertebrate*, ecology/ecosystem*, nutrition/diet*

214 **FRECKMAN, D.W., and R. MANKAU. 1986. Abundance, distribution, biomass and energetics of soil nematodes in a northern Mojave Desert ecosystem. Pedobiologia 29(2):129-142.**

Nematodes were extracted from soil samples [at Rock Valley] taken weekly for one year down to 30 cm below the surface at different distances from 4 shrub species. The nematode fauna was divided into four trophic groups (fungal feeders, plant feeders, bacterial feeders, and omnivore-predators). Nematode numbers decreased with increasing depth and distance from the shrubs. (Authors) *Keywords:* IBP*, perennial plants*, invertebrate*, ecology/ecosystem*, nutrition/diet*

215 **FRECKMAN, D.W., R. MANKAU, and S.A. SHER. 1975. Biology of nematodes in desert ecosystems. US/IBP Desert Biome Res. Memo. 75-32. Utah State University, Logan, 11 pp.**

Soil samples were collected weekly from four plant shrubs at Rock Valley from March 1973 to December 1974. The following information, derived from an April 1974 weekly sampling period, is given for nine samples at three depths and distances from the shrubs: mean number of nematodes/500 cm^3, corrected for extraction efficiency; mean individual weights; biomass; O_2 consumption in ml $* m^{-2} * wk^{-1}$; and calorific equivalents of O_2 consumption in cal/m^2. The data for the nematode community from 0-10 cm at the base of the shrubs during the week showed the number of nematodes/ 500 cm^3 soil to be 678, the mean individual nematode weight to be 0.277 µg, the total O_2 consumption to be 22 ml $O_2 *$ m-2 $* wk^{-1}$ and the calorific equivalent to be 106 cal $* m^{-2} * wk^{-1}$. The estimates of annual metabolism and productivity will be determined after studies on cryptobiosis in nematodes of desert soils have been completed. Analysis of the main effects during the 1974 Rock Valley study, such as the effect of seasonal distribution, shrubs, horizontal and vertical distribution on the nematode trophic groups, is presented. The seasonal distribution at Rock Valley in 1973 showed a significantly lower nematode density from April to July than in the winter months. Comparisons of the nematode community structure, nematode numbers/500 cm^3, biomass and geographical distribution are given for the Jornada, Curlew Valley and Silverbell sites. Analysis of the trophic levels at the four validation sites shows a greater percentage of microbial feeders (50-55%), in the nematode populations at Jordan, Silverbell and Rock Valley; whereas, at the Curlew Valley site, plant parasites represent 60% of the population. (Authors) *Keywords:* IBP*, perennial plants*, invertebrate*, nutrition/diet*, physiology*, ecology/ecosystem*

216 **FRECKMAN, D.W., S.A. SHER, and R. MANKAU. 1974. Biology of nematodes in desert ecosystems. US/IBP Desert Biome Res. Memo. 74-35, 10 pp.**

The results of a 14-week sampling period (April, 1973-July, 1973) in which nematode trophic levels are related to depth and distance from four shrubs are reported. The greatest numbers of nematodes in all trophic levels occurred at the top 10 cm near the plant. Numbers of nematodes decreased significantly with increasing distance from all plants at all trophic levels. Of the plant hosts, *Ambrosia dumosa* (formerly *Franseria dumosa*) and *Krameria parvifolia* showed no significant differences in numbers of plant parasites with increasing depth and *Lycium andersonii* and *Larrea divaricata* had significant decreases at all trophic levels with increasing depth. Preliminary sampling was begun at the three validation sites not previously sampled. Biomass and numbers of nematodes found at the Curlew Valley, Utah, and Tucson, Arizona, sites are discussed. Nematode biomass and density ranged from a low 0.034 g/m^2 and 308 nematodes/500 cm^3 soil at interspaces between plants at Rock Valley, Nevada, to a high of 0.310 g/m^2 and 3225 nematodes/500 cm^3 soil at Curlew Valley, Utah. Twenty-four nematode species thus far identified at the three sites are compared. Eleven of the 15 plant parasitic species identified occurred at Curlew Valley, Utah. (Authors) *Keywords:* IBP*, perennial plants*, invertebrate*, nutrition/diet*, ecology/ecosystem*

217 **FRENCH, N.R. 1963. Fallout and natural populations. In: Proceedings of the First International Conference on Wildlife Disease, High View, NY, June 1962, pp. 152-156.**

Discusses the fate and effects of radioactive fallout in natural populations, focusing on both internal and external emitters. The reproductive system appears to be the most susceptible to radiation damage. 100 rads is estimated as the dose that might be the threshold between survival and extinction for a population of small mammals. (TPO) *Keywords:* vertebrate*, mammal*, life history*, radiation*

218 **FRENCH, N.R. 1964. Description of a study of ecological effects on a desert area from chronic exposure to low level ionizing radiation. USAEC Report UCLA 12-532, 27 pp.**

A study of radiation effects on a desert ecological system is being conducted at the AEC Nevada Test Site. A circular 20-acre study area is fenced to confine the rodent population. The area is irradiated by a Cs-137 source which is partially shielded to reduce the dose rate at ground level close to the source. Small mammals are expected to receive about 1 r/day. Radiation dose to the kangaroo rats and pocket mice is being measured by small thermoluminescent dosimeters attached externally to the animals. Animals are individually marked. The populations of irradiated and control plots are censused at monthly intervals by live trapping. Mortality rates and production of young will be compared. Investigations of native vegetation, reptiles and arthropods are also being conducted. (Author) *Keywords:* vegetation*, invertebrate*, reptile*, mammal*, life history*, radiation*

219 **FRENCH, N.R. 1965. Radiation and animal populations: problems, progress and projections. In: (Hungate, F.P., Ed.) *Radiation and Terrestrial Ecosystems*, Health Physics 11:1557-1568.**

A review of recent literature suggests the importance of measuring the functional efficiency of irradiated populations. Population ecology provides methods suitable for evaluating the performance of populations. Dosimetry in radiation studies is simplified by new microthermoluminescent dosimeters. A population can be irradiated by administration of a single acute exposure of each individual animal, by chronic exposure of a large study area with an established population, or by administration of an isotope for internal exposure of the animals. Irradiation may impair a population primarily through reduction in fertility, and to some extent by reduction of life-span. In mammalian populations, reduced fertility would not under ordinary conditions be hazardous to survival, except when other environmental stress causes a shift in the age structure of the populations to the point where reproduction by older individuals is important to maintenance of the population. (Author) *Keywords:* vertebrate*, mammal*, life history*, radiation*

220 **FRENCH, N.R. 1966. Irradiated desert rodent populations. In: (Sacher, G.A., Ed.) *Radiation Effects on Natural Populations*, pp. 22.**

This paper describes briefly the radiation facility being used at the Nevada Test Site to test the effects of chronic, low level radiation on wild species of rodents. (TPO) *Keywords:* mammal*, radiation*

221 **FRENCH, N.R. 1967. Comparison of radioisotope assimilation by granivorous and herbivorous mammals. In: (Aberg, B., and F.P. Hungate, Eds.) *Radioecological Concentration Processes*, Proceedings of the International Symposium, Stockholm, April 1966 (CONF-660405), pp. 665-673.**

Fractional uptake and effective half-life of ingested I-131 in a granivore (kangaroo rat), a herbivore (rabbit), and a rodent of intermediate dietary habits (deer mouse) were compared. The granivore showed the greatest thyroidal uptake and the longest effective halflife. Both uptake and effective half-life were much reduced in kangaroo rats on a high protein diet. This is attributed to increased urinary loss of iodine. The uptake was slightly increased, but effective halflife was much reduced in rabbits on a diet of alfalfa hay. This is attributed to the bulk of the diet, which decreased efficiency of absorption. Absorption of radioiodine from isolated intestinal loops was similar in animals on different diets, and was essentially similar in herbivores and granivores. Absorption from the duodenum appeared to be greater in the granivore than in the herbivore. The stable iodine content of the diet and renal loss of iodide are probably the most important factors influencing thyroidal assimilation of ingested radioiodine. The amount of radioiodine ingested in a contaminated environment by an herbivore was estimated to be 48 times greater than by a granivore, and as a result the thyroid radioiodine is 8 times greater in the herbivore. Radiation dose to the thyroid would be similar in both types of animals, because the small size of the gland in the granivore reduces absorption of energy of the β radiation. (Author) *Keywords:* mammal*, nutrition/diet*, physiology*, radiation*

222 **FRENCH, N.R. 1969. Radiation sensitivity of rodent species. Nature 222:1003-1004.**

A laboratory colony of *Peromyscus maniculatus* was exposed to chronic radiation at a rate of approximately 1.23 R/day.

The intrinsic rate of natural increase was 0.1897 in the irradiated mice and 0.3134 in the controls. Within controls, males had a significantly greater life expectancy at birth. Chronic radiation reduced the average life span in both sexes. Computer simulations were used to investigate the significance of the radiation damage to a natural population of *Peromyscus*. Simulations suggested that wild populations were closely balanced and small additional stresses, such as chronic radiation damage, would be detrimental to the population, even perhaps causing extinction of the population. (TPO) *Keywords:* mammal*, radiation*

223 **FRENCH, N.R. 1970. Chronic low-level gamma irradiation of a desert ecosystem for five years. In: (Grauby, A., Ed.) Proceedings of the Symposium International de Radioecologie, Cadarache, France, September 1969 (CONF-690918, Volume 2), pp. 1151-1167.**

Populations of vertebrate animals, certain insects, and plants were studied in three enclosed 8-hectare areas located in the Mojave desert. They were enclosed by a fence to prevent rodents from entering or leaving the study areas. One area was irradiated almost continuously at a dose rate of 80 to 500 mr/hr. Animal populations were examined by capturing, marking and releasing individuals. Plants were examined for growth and for production of leaves, flowers, fruit, and seeds. The life span of the population of pocket mice, *Perognathus formosus*, in the irradiated area was shorter than in the other areas. No difference was detected in the numbers of a small lizard, *Uta stansburiana*, that survived from year to year. Females of a larger but less numerous species of lizard have become sterile in the irradiated area. All vertebrate animals in the irradiated area have received exposures of 1 to 2r/day. Certain species of plants have produced fewer flowers and fruits in the irradiated area. Plants have received exposures of 4 to 7r/day. Although wild populations of small mammals are surprisingly sensitive to damage from chronic low-level radiation exposure, they are evidently able to persist under these conditions. There may be certain compensating mechanisms that become operative when the population is subjected to radiation stress. (Author) *Keywords:* vegetation*, reptile*, mammal*, life history*, nutrition/diet*, radiation*

224 **FRENCH, N.R., and H.W. KAAZ. 1968. The intrinsic rate of natural increase of irradiated *Peromyscus in* the laboratory. Ecology 49:1172-1179.**

The effect of continous low-level exposure to Y radiation on a population of deer mice (*Peromyscus maniculatus sonoriensis*) in the laboratory was studied. The average dose rate was slightly greater than 1 R/day. One group was exposed as adults, with irradiation beginning when they were weaned (age 3 to 4 weeks); another group was the offspring of the irradiated adults, hence these animals were irradiated since conception. Descendants from three separate field populations were present in each group. The intrinsic rate of natural increase was increased in animals irradiated as adults as a result of an elevation of the instantaneous rate of birth and a reduction of the instantaneous death rate. Animals irradiated since conception showed a lower intrinsic rate of natural increase than the controls. Life span was shortened by irradiation and age specific natality was reduced by radiation, both by lowering the maximum number of young per female and by shortening the reproductive life spans of females. Reduction was greatest in the animals irradiated since conception. There was evidence of hyperovulation in the group irradiated as adults. There was variation among the three field populations represented, both in reproductive capacity of control animals and in sensitivity to radiation. Among controls, the population from the lowest field elevation had the greatest intrinsic rate of natural increase. This population showed the least sensitivity to radiation. The greatest sensitivity to radiation was in the population from intermediate elevations. It was concluded that field populations of *Peromyscus* living in favorable environments might withstand the degree of reduction induced by this level of radiation exposure. Field populations living under less favorable conditions possibly could not. (CH) *Keywords:* mammal*, life history*, nutrition/diet*, radiation*

225 **FRENCH, N.R., and K.H. LARSON. 1963. Environmental pathways of radioactive iodine from nuclear tests in arid regions. In: (Schultz, V., and A.W. Klement, Jr., Eds.) *Radioecology*, Proceedings of the First National Symposium on Radioecology, pp. 77-81.**

Varying quantities of radioiodine are liberated to the environment by nuclear detonations, reactor tests and accidents, and chemical processing of spent fuel elements. The amount released depends upon the physical and chemical characteristics of the reactions at the time of release of the fission products. Radioiodine is probably adsorbed on surfaces that are available. Whether incorporated in particles, as an aerosol, or as a gas, the radioiodine collects on the leaves of desert plants which expose considerable area to the passing air stream. It appears that this is the biologically important means of retention of radioiodine released to the environment. Ingestion is considered the only important route of entry of radioiodine into the animals living in the contaminated environment. Animals exposed to radioiodine produced by nuclear reactions, but prevented from ingesting contaminated material, showed little or no radioiodine in their thyroids; animals that ingested the contaminated material showed great increases in thyroid radioiodine. Further, thyroid radioiodine of animals in a contaminated environment continues to increase for several days after contamination. This indicates that radioiodine was deposited in the environment rather than being inhaled during the single passage of the contamination. The contaminated food supply is the major source of ingested radioiodine. The contaminated soil surface also makes an important contribution to ingested radioiodine in native animals. This soil may be taken in with the food by accidental ingestion as the animal digs or moves about on the soil surface, or may be ingested by licking and cleaning the fur. Each of these routes of ingestion has been demonstrated with kangaroo rats in laboratory experiments. The abundance of radioiodine in radioactive contamination provides material that is widely distributed in detectable quantities. Its deposition on forage plants and the rapid assimilation and concentration in the animal thyroid gland provides a convenient tracer of released fission products. The same properties of assimilation and concentration make radioiodine one of the major potential hazards to vertebrate animals. Considerable effort is being and has been devoted to study of the physiology of iodine in the animal body. At present, very little is known of the mechanism of distribution, retention, and circulation of radioiodine in the environment. There is urgent need for concentrated study of the environmental pathways of radioiodine prior to the time it is incorporated in the animal. (Authors) *Keywords:* vegetation*, vertebrate*, mammal*, life history*, nutrition/diet*, physiology*, radiation*

226 **FRENCH, N.R., P. HAYDEN, and T. TAGAMI. 1965. The source of ingested radioactivity in desert rodents. Health Physics 11:637645.**

Using ^{131}I as a tracer, comparisons were made of the radioactivity ingested by kangaroo rats when eating contaminated food and when living on contaminated sand. Different methods of exposure served to differentiate the sand consumed with the food, the sand consumed accidentally while digging or searching for food, and the sand consumed by licking the fur. Results indicated that all routes of entry are important. On the basis of further tests, the data were extrapolated from the laboratory tests to field conditions. Deposition of airborne ^{131}I was proportional to the surface areas of materials under consideration; 1 g of sand therefore contained nine times the radioactivity of 1 g of pearl barley seeds. When hulls were removed from the contaminated grain by the rodents, only 16 percent of the radioactivity on the food was consumed. It is estimated that under field conditions kangaroo rats obtain 70 to 80 percent of their internal emitters directly or indirectly from the sand. (Authors) *Keywords:* vegetation*, mammal*, nutrition/diet*, radiation*

227 **FRENCH, N.R., B.G. MAZA, and A.P. ASCHWANDEN. 1966. Periodicity of desert rodent activity. Science 154:1194-1195**.

The radiation dose detected by microthermoluminescent dosimeters attached to pocket mice, *Perognathus formosus* indicated the amount of time these animals were active on the surface of the ground. Radiation was from an elevated, partially shielded source in the center of the 8-hectare enclosure. The rodents are almost entirely inactive in midwinter but spend 30 to 40% of their time above ground in the summer months. Periods of activity increase gradually through the spring. These results support laboratory findings that members of this genus undergo periods of torpor in response to low ambient temperatures or food shortage. That this adaptation may enhance survival is indicated by the longevity of marked individuals of a related species. (Authors) *Keywords:* mammal*, ecology/ecosystem*, methods*

228 **FRENCH, N.R., B.G. MAZA, and A.P. ASCHWANDEN. 1967. Life spans of *Dipodomys* and *Perognathus* in the Mojave Desert. Journal of Mammalogy 48:537-548.**

Rodent populations in four 20-acre plots were studied: three of the plots were fenced to prevent dispersal, and one of these plots was subjected to ionizing radiation; the fourth plot was unfenced. Mean life spans (defined as the time between the first and last appearance in the trapping records) in the fenced, unirradiated plots were between 3.7 and 5.0 months for *Perognathus formosus, P. Zongimembris, Dipodomys merriami* and *D. microps*. Mean life spans were shorter in the irradiated plot and shortest in the unfenced plot. Greatest mortality occurred in the few months following first capture. Some *P. longimembris* survived 3-4 years. (TPO) *Keywords:* mammal*, life history*, radiation*

229 **FRENCH, N.R., B.G. MAZA, and H.W. KAAZ. 1969. Mortality rates in irradiated rodent populations. In: (Nelson, D.J., and F.C. Evans, Eds.) *Symposium on Radioecology*, Proceedings of the Second National Symposium on Radioecology (CONF-670503), pp. 46-52.**

Survival curves were computed for the pocket mouse, *Perognathus formosus*, populations of three fenced 20-acre plots.

The animals of one plot were irradiated at a rate of approximately 1 R/day. The data are suggestive of a shorter life span induced by radiation, but are not conclusive. Survival curves for irradiated (1 R/day) and control *Peromyscus maniculatus* in the laboratory show significant differences between the two groups and between sexes in each group. Extrapolation of comparable shortening of life spans by radiation to survival rates of field populations of the same species indicates the importance of chronic radiation exposure from widespread radioactive contamination in a natural situation. The magnitude of the effect is related to the natural life spans in the field, and varies with the environment. A relatively long-lived species may suffer from such exposure, while a naturally short-lived species will be unaffected. There was no indication of increased survival rates of the wild species under chronic low level exposure as has been indicated in similarly exposed laboratory rats and mice. (Authors) *Keywords:* mammal*, life history*, radiation*

230 **FRENCH, N.R., T.Y. TAGAMI, and P. HAYDEN. 1968. Dispersal in a population of desert rodents. Journal of Mammalogy 49:272-280.**

Dispersal of 2 species of kangaroo rats and 2 species of pocket mice in the Mojave Desert was examined by live-trapping intensively an 8-ha (20-acre) area, and by setting rows of live-traps at 152-m (500 ft) intervals out to 914 m (3,000 ft) from the area. Dispersal distances of *Perognathus formosus* were arranged in a frequency distribution. Dispersal appears to be nonrandom. There were too many moves to great distances and too few to intermediate distances for dispersal to be considered random. The results support the hypothesis that some members of the population have an instinct to disperse, and that their moves are long distance ones. Both young and old animals made dispersal movements, some more than once. We estimate 25 to 30% of the *P. formosus* made dispersal movements during the period of 1 year. Kangaroo rats wander during the nonbreeding season, but our sampling was not adequate to evaluate dispersal of these rodents. (Authors) *Keywords:* mammal*, ecology/ecosystem*

231 **FRENCH, N.R., C.D. JORGENSEN, M.H. SMITH, and B.G. MAZA. 1971. Comparison of Some IBP Population Estimates Methods for Small Mammals. Special Report, July 1971, Office of the Chairman, USNC/IBP.**

Results are reported of a field test conducted in July of 1970 to determine the accuracy of population estimation procedures for small mammals to be utilized in the United States contributing programs to the International Biological Program (IBP). The basis for comparison of sample results was the known population densities of rodents in two 9-hectare (20-acre) enclosures. The test was partially successful. Among the previously reported sampling procedures for small mammals, the Jolly procedure gives the best estimate for live trapping results, and the Hanson procedure gives the best estimate from data based on removal trapping. The new procedures tested, one a grid with assessment lines, the other a grid surrounded by an auxiliary band of traps, did not result in adequate information for testing precision of the population estimates because the enclosures with known densities were not sufficiently large to cover the current designs of these procedures. Valuable information about these procedures was obtained, however, in the form of effective area of a 12 x 12 standard grid and knowledge of where animals came from that appeared in the traps, as well as where those were that failed to appear. (Authors) *Keywords:* IBP*, mammal*, ecology/ecosystem*, methods*

232 **FRENCH, N.R., B.G. MAZA, H.W. KAAZ, and A.P. ASCHWANDEN. (Year unknown). Ecological and Environmental Effects from Local Fallout from Cabriolet. Laboratory of Nuclear Medicine and Radiation Biology, University of California, Los Angeles, CA. Project CEP-67.3, 9 pp.**

Live-trapping and marking of small mammals in two 20-acre areas, located 5,000 feet north of Cabriolet ground zero, revealed no major changes in the rodent populations that could be attributed to radiation exposure. Dose to the animals was estimated to be some hundreds of rads in a period of five months. Numbers of animals of each species were estimated in the fall season prior to the nuclear test, and again in the summer following the event. The population of the area that was contaminated by fallout showed a greater increase in numbers than the population of the control area. Survival of marked animals appeared to be greater in the contaminated area. There was no indication of extensive emigration from either study area. The methods employed in this study were designed to detect changes of major proportions, and the differences observed in the populations of the two study areas are not considered significant. (Authors) *Keywords:* mammal*, radiation*

233 **FRENCH, N.R., B.G. MAZA, H.O. HILL, A.P. ASCHWANDEN, and H.W. KAAZ. 1974. A population study of irradiated**

desert rodents. Ecological Monographs 44:45-72.

Describes results of experiments initiated in 1963 to examine the effects of long-term low-level radiation exposure on desert populations of plants and animals. In years of adequate food *Perognathus formosus* populations could increase by a factor of 5 or more; in poor years there may have been no reproduction. Radiation exposures averaging 211-360 r/yr reduced survival, particularly before the age of 6 months. The instantaneous rate of death was increased, future life expectancy was reduced, and the intrinsic rate of increase was reduced in irradiated populations compared with controls. There was evidence indicating an increased birth rate in the irradiated population. Only in the most unfavorable periods, when reproduction is curtailed by natural forces, will the threshold levels of artificial radiation insult on the natural population be discernible. A rapid turnover of generations prevents a population from accumulating damaging effects of low-level exposure. Estimates of food requirements suggested that food supply may be an important limiting factor. (TPO) *Keywords:* vegetation*, mammal*, life history*, nutrition/diet*, radiation*

234 **FRIESEN, H.N. 1992. Summary of the Nevada Applied Ecology Group and Correlative Programs. DOE/NV-357 (Version 2). U.S. Department of Energy, Nevada Field Office. Las Vegas, NV, 140 pp.**

This report presents the findings of the Nevada Applied Ecology Group and correlative programs on the NTS. The group's objectives were to: (1) delineate locations of contamination, (2) determine concentrations in ecosystem components, (3) quantify rates of movement among ecosystem components, (4) evaluate radiological hazards of plutonium, (5) identify areas which need to be cleaned up or treated, and (6) develop techniques for cleanup or treatment. The Nevada Applied Ecology Group conducted studies of plutonium, uranium, americium, and other radionuclides in the environment on and near the Nevada Test Site from July 1970 to September 30, 1986. About 540 reports and papers were prepared during this 16-year effort. These were progress reports, papers presented at symposia, or papers published in peer-reviewed journals. The Nevada Applied Ecology Group compiled and published ten collections of progress and research reports. The last compilation consisted of reports presented at the Plutonium Information Conference in June 1983. Research reports for work conducted from June 1983 through September 1986 have not been compiled into one document. However, some of the concluding work has been published in peer-reviewed journals since project termination. This book is organized to present findings of the Nevada Applied Ecology Group and correlative programs in accordance with the originally stated objectives of the Nevada Applied Ecology Group. This plan, in essence, traces plutonium from its injection into the environment to movement in the ecosystem to development of cleanup techniques. Information on other radionuclides was also obtained and will be presented briefly. (Author) (CAW) *Keywords*: NAEG*, radionuclide inventory*, microbiota, vegetation*, vertebrate*, ecology/ecosystem*, radiation*, revegetation*

235 **FULLER, R.G., and W.E. MARTIN. 1969. Bioenvironmental safety. In: Technical Discussions of Offsite Safety Programs for Underground Nuclear Detonations (NVO-40, Rev. 2), pp. 301-311.**

The Bioenvironmental Safety program sponsored by the AEC-NV00 is concerned with the more subtle and indirect consequences of nuclear testing: the potential exposure of people to internal radiation via food chains, direct or indirect damage to wildlife populations, and environmental disturbances that may lead to undesirable ecosystem changes. Objectives include preshot prediction of effects, recommendation of courses of action to mitigate significant adverse effects, and post-shot documentation of ecological consequences. The methods used to achieve these objectives are the usual techniques of applied ecology: mission-oriented ecological surveys, analysis of ecosystem dynamics, experimentation when required, and application of relevant ecosystem models for predictive purposes. These concepts are equally applicable to any type of nuclear detonation, but bioenvironmental safety problems encountered will vary with the location and with the type of event. In general, the safety standards and the basic approaches to ensure that detonations meet those standards will remain the same. As the use of nuclear explosives advances from the testing phase into practical utilization in engineering projects, mining, and related uses, the same type of bioenvironmental safety efforts will be required, and the methods now being developed and used will be adaptable to future needs. (Authors) *Keywords:* management*, radionuclide inventory*, radiation*, methods*

236 **FURMAN, D.P., and F.J. RADOVSKY. 1963. A new species of *Ornithonyssus* from the white-tailed antelope squirrel, with a re-diagnosis of the genus *Ornithonyssus* (Acarina: Dermanyssidae). Pan-Pacific Entomologist 39:89-98.**

Ornithonyssus aridus, is described from *Ammospermophilus leucurus* from deserts of California, Nevada and Utah. *Ornithonyssus* is redefined and 15 spp. are included. *Neoichoronyssus* is synonymized with *Ornithonyssus*. (Authors) *Keywords:* invertebrate*, mammal*, invertebrate*, taxonomy*

237 **GABBERT, W.D., B.W. SCHULTZ, J.P. ANGERER, and W.K. OSTLER. 1995. Plant Succession on Disturbed Sites in Four Plant Associations in the Northern Mojave Desert. In: Proceedings of the Wildland Shrub and Arid Land Restoration Symposium, Las Vegas, NV, October 19-21, 1993. Roundy, B.A., E.D. McArthur, J.S. Haley, and D.K. Mann (Compilers). Gen. Tech. Rep. INT-GTR-315. U.S. Department of Agriculture, Forest Service; Intermountain Research Station, Ogden, UT, pp. 183-188.**

The U.S. Department of Energy (DOE) is studying Yucca Mountain, Nevada, to determine the mountain's suitability for the long-term storage of high-level nuclear waste. DOE has made a commitment to reclaim all lands disturbed by the project, and to return disturbed sites to a stable ecological state, with a vegetation composition and productivity similar to predisturbance conditions. During 1991 and 1992 EG&G Energy Measurements implemented a study to determine which plant species naturally invade disturbed sites in the Yucca Mountain Project area. Fifty-seven study plots were established on disturbances in four primary vegetation associations. Measurements of absolute perennial plant density occurred in three to six belt transects in each study plot. Mean density was calculated and density values from the disturbed sites were compared with those of undisturbed sites. Across all four vegetation associations, needle-leaf rabbit-brush (*Chrysothamnus teretifolius*) had the highest relative density in disturbed sites, but was not a major component in undisturbed sites. Bursage (*Ambrosia dumosa*) had the highest density in undisturbed sites, but also had high densities in disturbed areas. Total species density was higher in undisturbed sites, compared to disturbed sites. The results of this study will aid in the development of reclamation plans for site-specific disturbances at Yucca Mountain. (Authors)
Keywords: YMSCO*, perturbations*, perennial plants*, ecology/ecosystem*

238 **GAMON, J.A., L.K. FENSTERMAKER, and D.A. SIMS. 1999. Optical detection of early CO_2 treatment effects at the Nevada Desert FACE Facility. In: Symposium Abstracts, The Ecological Society of America 84th Annual Meeting, August 8-12, 1999, Spokane, WA.**

We explored evidence for CO_2 treatment effects at the Nevada Desert FACE facility (NDFF) in an El Niño year using spectral reflectance of leaves and canopies. At the leaf scale, several indices of pigment content and activity exhibited significant differences between CO_2 treatments, but these differences were not consistent across species and seasons, indicating that leaf-level physiology was strongly influenced by phenology. For example, in June, chlorophyll content was higher in elevated CO_2 than in ambient CO_2, but in August this pattern was reversed for one species (*Larrea tridentata*) following a midsummer leaf flush. At the canopy scale, during periods of photosynthetic activity, both the normalized difference vegetation index (NDVI), and the water band index (WBI) were consistently higher in elevated CO_2 than in ambient CO_2 for five species measured, indicating greater green leaf area and canopy water content under elevated CO_2. The clear results at the canopy scale suggest a remarkably strong response of this Mojave Desert ecosystem to elevated CO_2 during conditions of abundant moisture, and demonstrate the utility of non-destructive, optical sampling. Further work will continue to explore possible treatment effects under what is expected to be a drought (La Niña) year. (Authors)
Keywords: FACE*, perturbations*, climate*, perennial plants*, physiology*, methods*

239 **GARCIA, P.L. 1960. The influence of *Larrea divaricata* and *Atriplex canescens* on soil pH, electrical conductivity and soluble sodium content. Master's Thesis, New Mexico Highlands University, Las Vegas, NM, 63 pp.**

Samples were collected from the Tularosa Basin, New Mexico, and Frenchman Flat, Nevada, to determine the influence of desert shrubs on the soils beneath them. Measurements included mean pH, mean electrical conductivity, and amount of soluble sodium. The most significant observation was the lowering of soil pH from samples collected beneath *Larrea divaricata*. (TPO) *Keywords:* soil property*, perennial plants*, ecology/ecosystem*

240 **GERMANO, D.J., R.B. BURY, T.C. ESQUE, T.H. FRITTS, and P.A. MEDICA. 1994. Range and Habitats of the Desert Tortoise. In: Biology of North American Tortoises. Bury, R.B., and D.J. Germano (Eds.), Fish and Wildlife Research 13, U.S. Department of the Interior National Biological Survey, Washington, D.C.**

We determined the current range of the desert tortoise (*Gopherus agassizii*) based on the available latest data from government agencies, the literature, and our experience. We developed the first detailed range map of this species and summarized information about habitat preferences. New records of occurrences were incorporated, and some peripheral localities of questionable authenticity were deleted. The distribution of *G. agassizii* covers the broadest range of latitude, climatic regimes, habitats, and biotic regions of any North American tortoise. The northern portion of its range is in the

Mojave Desert of southeastern California, southern Nevada, southwestern Utah, and northwestern Arizona. The central portion of the range consists of several subdivisions of the Sonoran Desert in southeastern California, western and southern Arizona, and western Sonora, Mexico. The southern edge of its range is in the semitropical Sinaloan thornscrub and Sinaloan deciduous forest of eastern Sonora and northern Sinaloa, Mexico. This species has marked geographic differences but seems to construct burrows throughout its range. (Authors) *Keywords:* desert tortoise*, ecology/ecosystem*

241 **GERTSCH, W.J., and D.M. ALLRED. 1965. Scorpions of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 6(4), 15 pp.**

The scorpion fauna of the Nevada Test Site was investigated from 1959-1964 as a part of the ecological study of the area and the effects of nuclear weapons. Nine species of scorpions live in the area, but only two species, *Vejovis confusus* and *Hadrurus spadix* may be considered abundant. Data given for each species includes distribution and abundance, description and taxonomy, sex ratio and seasonal occurrence. (BBM) *Keywords:* invertebrate*, ecology/ecosystem*, taxonomy*

242 **GILBERT, R.O. 1976. Vegetation Sampling Protocol for Inventory – Area 13 of NTS. In: *Nevada Applied Ecology Group Procedures Handbook for Environmental Transuranics*. White, M.G., and P.B. Dunaway (Eds.). NVO-166, U.S. Energy Research and Development Administration, Nevada Operations Office, Las Vegas, NV, pp. 127-131.**

This paper described the vegetation sampling protocol used by NAEG researchers for the inventory of Pu-239-240. This protocol ensures that vegetation samples are obtained within a prescribed distance from each random soil sampling location. (CAW) *Keywords:* NAEG*, vegetation*, radiation*, methods*

243 **GILBERT, R.O., and E.H. ESSINGTON. 1977. Estimating total 239-241 Pu in blow-sand mounds of two safety shot sites. In: *Transuranics in Desert Ecosystems*. White, M.G., and P.B. Dunaway (Eds.). NVO-181, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 367-421.**

This paper, in conjunction with the companion paper by Essington *et al.* (1977), describes a study for estimating the total amount (inventory) of ^{239,240}Pu in blow-sand mounds at two safety-shot sites: Area 13 (Project 57) on the Nellis Air Force Base and Clean Slate 3 on the Tonopah Test Range in Nevada. The total amount in blow-sand mounds at these two sites is estimated to be 5.8 ± 1.3 (total ± standard error) and 10.6 ± 2.5 curies, respectively. The total ^{239,240}Pu in mounds plus desert pavement areas, both to a depth of 5 cm below desert pavement level, is estimated to be 39 ± 5.7 curies at the Project 57 site and 36 ± 4.8 curies at Clean Slate 3. These estimates are compared with the somewhat higher estimates of 46 ± 9 and 37 ± 5.4 curies reported by Gilbert (1977) that pertain to only the top 5 cm of mounds and desert pavement. The possibility is discussed that these differences are due to sampling variability arising from the skewed nature of plutonium concentrations, particularly near ground zero. Estimates of the total ^{239,240}Pu mound inventory are broken down into estimates for mound tops and mound bottoms of five different mound types. Roughly 60 to 65 percent of the total mound inventory is estimated to be in mound bottoms even though plutonium concentrations on a per gram dry soil basis are roughly twice as large in mound tops as in mound bottoms. This is explained by an average mound bottom to mound top weight ratio of from 3 to 8, depending on mound type. Mound top to desert pavement ratios tend to be greater than 1 on a concentration per gram basis and less than 1 on a concentration per unit area basis. The ratio of mound bottom to desert pavement plutonium concentrations tends to fluctuate about 1 for both concentration units. For mounds disturbed by the burrowing activities of animals, the mound tops, mound bottoms, and desert pavement tend to have about the same concentrations. The statistical procedures used to estimate mound and desert pavement inventory are given in general in the main text and in detail in Appendices A and B. Information on the number, size, and weight of sampled mounds is presented. It is estimated that about 17 ± 5.7 and 31 ± 8.7 percent of the Project 57 site and Clean Slate 3, respectively, are covered by the five mound types. The most common mound type at both sites is the "Complex" mound, a relatively large mound that may encompass several shrubs and/or grasses. It is estimated to cover about 15 percent of both sites. Diffuse mounds (low, flat mounds covered with grass) are estimated to cover about 12 percent of Clean Slate 3. There is some preliminary evidence that the ratio of mound top to mound bottom plutonium concentrations for Diffuse mounds at Clean Slate 3 may tend to increase with distance from ground zero. However, the data for other mound types at both study sites do not show this tendency. More data would be required to study the question further. The change in ^{239,240}Pu to ^{241}Am ratios over time at the two study sites is discussed. The median ratio changed from 9.8 in 1973 to 5.7 in 1976 at the Project 57 site, and from 22.6 in 1974 to about 20.9 in 1976 at Clean Slate 3. Information is presented on the variability between replicate 10-gram soil aliquots for ^{239,240}Pu and ^{241}Am from four mound types at Clean Slate 3. The coefficients of variation range from 6 to over 90 percent. Interlaboratory comparison results are not available at this time. The information presented here supplements that given by Essington *et al.* (1977). These authors discuss in some detail an earlier mound study (Mound Study 1) as well as additional information on field sampling design and plutonium concentration ratios between mound tops, mound bottoms, and desert pavement. Data on uranium concentrations and FIDLER* readings taken over mound and desert pavement locations are also given, as is additional information on plutonium to americium ratios. Throughout this paper, ^{239,240}Pu and ^{241} Am are referred to as simply plutonium and americium, respectively. (Authors) *Keywords:* NAEG*, radionuclide inventory*, vegetation*, vertebrate*

244 GILBERT, R.O., J.H. SHINN, E.H. ESSINGTON, T. TAMURA, E.M. ROMNEY, K.S. MOOR, and T.P. O'FARRELL. 1988. Radionuclide Transport from Soil to Air, Native Vegetation, Kangaroo Rats and Grazing Cattle on the Nevada Test Site. Health Physics 55(6):869-887.

Between 1970 and 1986 the Nevada Applied Ecology Group (NAEG), U.S. Department of Energy, conducted environmental radionuclide studies at weapons-testing sites on or adjacent to the Nevada Test Site. In this paper, NAEG studies conducted at two nuclear (fission) sites (NS201, NS219) and two nonnuclear (nonfission) sites (Area 13 [Project 57] and Clean Slate 2) are reviewed, synthesized and compared regarding (1) soil particle-size distribution and physical-chemical characteristics of $^{239+240}$Pu-bearing radioactive particles, (2) $^{239+240}$Pu resuspension rates, and (3) transuranic and fission-product radionuclide transfers from soil to native vegetation, kangaroo rats and grazing cattle. The data indicate that transuranic radionuclides were transferred more readily on the average from soil to air, the external surfaces of native vegetation and to tissues of kangaroo rats at Area 13 than at NS201 or NS219. The $^{239+240}$Pu resuspension factor for undisturbed soil at Area 13 was three to four orders-of-magnitude larger than at NS201 and NS219, the geometric mean (GM) vegetation-over-soil $^{239+240}$Pu concentration ratio was from ten to 100 times larger than at NS201, and the GM GI-over-soil, carcass-over-soil and pelt-over-soil $^{239+240}$Pu ratios for kangaroo rats were about ten times larger than at NS201. These results are consistent with the finding that Area 13, compared with NS201 or NS219, has a higher percentage of radioactivity associated with smaller soil particles and a larger percentage of resuspendable and respirable soil. However, the resuspension factor increased by a factor of 27 at NS201 when the surface soil was disturbed, and by a factor of 12 at NS219 following a wildfire. The average (GM) concentration of $^{239+240}$Pu for the GI (and contents) of Area 13 kangaroo rats and for the rumen contents of beef cattle that grazed Area 13 were very similar (400 vs. 440 Bq kg^{-1} dry wt, respectively) although the variability between individuals was very large. The GM carcass-over-GI $^{239+240}$Pu concentration ratio for kangaroo rats at Area 13, Clean Slate 2, and NS201 were similar in value ($\sim 2x10^{-2}$), as were the GM GI-over-vegetation concentration ratios ($\sim 2x10^{0}$) (no statistical differences). The GM carcass-over-over-GI ratio for Area 13 kangaroo rats ($2x10^{-2}$) was 30 times larger (statistically significant) than the approximate calculated GM carcass-over-rumen concentration ratio ($7x10^{-4}$) for the beef cattle that grazed Area 13, indicating the possibility of greater transfer of $^{239+240}$Pu to tissues of kangaroo rats than to tissues of beef cattle. At NS201, the data indicated that the bioavailability of radionuclides to the carcass of kangaroo rats was ^{90}Sr>^{137}Cs>^{238}Pu>^{241}Am>$^{239+240}$Pu. The GM carcass-over-GI ratio for ^{90}Sr was about six times larger than for ^{137}Cs, about 30 times larger than for ^{238}Pu and about 60 times larger than for ^{241}Am and $^{239+240}$Pu (statistical differences). Also, the GM $^{239+240}$Pu-over-^{238}Pu ratios for pelt and GI were three to four times larger (statistically significant) than that for carcass, and the GM $^{239+240}$Pu-over-^{241}Am ratio for pelt was about two times larger (statistically significant) than that for carcass. (Authors) *Keywords:* NAEG*, radionuclide inventory*, vegetation*, mammal*, radiation*

245 GILBERTSON, R.L., and K.S. NEUHAUSER. 1981. Wood-Rotting Fungi on Structural Timbers at the NTS. SAND81-1538, Sandia National Laboratories, Albuquerque, NM, 20 pp.

Ten species of wood-rotting fungi were identified on structural timbers, i.e. lagging and rail ties of Douglas fir, in tunnels E, G, and N on the Nevada Test Site. All were brown-rot fungi, which selectively remove cellulose from wood and which cause rapid loss of strength. Five of the ten species have not previously been reported on mine timbers. Ventilation, which can keep the moisture level of the timbers low enough to prevent decay, appears to be the most influential parameter affecting fungal activity in the NTS tunnels. (Authors) *Keywords:* microbiota*, taxonomy*

246 GILES, K.R. 1976. Springs on the Nevada Test Site and Their Use by Wildlife. NERC-LV-539-26, U.S. Environmental Protection Agency, Las Vegas, NV, 18 pp.

During August 1972, natural springs located on the Nevada Test Site were surveyed to determine the use by wildlife and the effort required for improving flow. Each spring is described and its use by wildlife noted. Methods of improving spring flow are suggested. It is believed that minimal effort at most of the springs would result in a significant improvement of waterflow with resulting benefits to wildlife. The intention of the recommendations in this report is to encourage development of the Nevada Test Site springs and to maintain the wildlife now at the Site. There is no recommendation to bring in or support wildlife outside the Nevada Test Site area. (Author) *Keywords:* EPA*, hydrology*, wetlands*, vertebrate*, ecology/ecosystem*

247 GILES, K.R. 1979. A Summer Trapping Method for Mule Deer. EMSL-LV-0539-27, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Las Vegas, NV.

This report describes a summer mule deer trapping method which uses modified Clover traps in a circular corral with water as a bait. Drug restraint was used to facilitate safe handling of mule deer by the investigator. Fifteen mule deer were safely captured and outfitted with radio transmitters, ear tags, and reflective markers, and their movements monitored to determine migration patterns [on and off the NTS]. (Author) *Keywords:* EPA*, mammal*, methods*

248 GILES, K.R. 1997. Animal Investigation Program (AIP): A.I.P. Summary Report on and Around the Nevada Test Site from 1982-1995. Radiation and Indoor Environments National Laboratory, U.S. Environmental Protection Agency, Las Vegas, NV, 29 pp.

This report describes the Animal Investigation Program conducted from 1982 - 1995 by the Environmental Protection Agency's (EPA's), Radiation and Indoor Environments National Laboratory (R&IE), formerly Radiation Sciences Laboratory-Las Vegas. This laboratory operates an environmental radiation monitoring program in the region surrounding the Nevada Test Site. The surveillance program was designed to measure levels and trends of radionuclides in animals on and around the Nevada Test Site to ascertain whether world-wide fallout, current radiation levels, and associated doses, to the general public were in compliance with existing radiation protection standards. The surveillance program additionally had the responsibility to take action to protect the health and well-being of the public in the event of any accidental release of radioactive contaminants. Comparison of the measurements and sample analysis results indicated that no significant amounts of biological radionuclides had been detected in the near offsite areas or on the NTS, except in animals drinking water that drains from tunnels in Area 12. (Author) *Keywords:* EPA*, vertebrate*, radiation*

249 GILES, K.R. 1997. Animal Investigation Program (AIP): A.I.P. Summary Report on and Around the Nevada Test Site from 1982-1995. EPA-402-R-97-009, Radiation and Indoor Environments National Laboratory, U.S. Environmental Protection Agency, Las Vegas, NV, 37 pp.

This report describes the Animal Investigation Program conducted from 1982--1995 by the Environmental Protection Agency's (EPA's), Radiation and Indoor Environments National Laboratory® and IE), formerly Radiation Sciences Laboratory-Las Vegas. This laboratory operates an environmental radiation monitoring program in the region surrounding the Nevada Test Site. The surveillance program was designed to measure levels and trends of radionuclides in animals on and around the Nevada Test Site to ascertain whether world-wide fallout, current radiation levels, and associated doses, to the general public were in compliance with existing radiation protection standards. The surveillance program additionally had the responsibility to take action to protect the health and well-being of the public in the event of any accidental release of radioactive contaminants. Comparison of the measurements and sample analysis results indicated that no significant amounts of biological radionuclides had been detected in the near offsite areas or on the NTS, except in animals drinking water that drains from tunnels in Area 12. (Author) *Keywords:* EPA*, vertebrate*, radiation*

250 GILES, K.R., and J. COOPER. 1985. Characteristics and Migration Patterns of Mule Deer on the Nevada Test Site, EPA/600/4-85-030, U.S. Environmental Protection Agency, Las Vegas, NV.

When NTS deer migrate, the majority of the animals stay within the confines of the NTS or the Nellis Bombing Range, and present little potential for radiation transport off the NTS. Also, the few deer that leave the NTS area do so during the winter when they cannot legally be hunted in Nevada. The one exception from the apparent migration pattern was a buck that was followed by telemetry until the end of April, when the animal could no longer be located, and was harvested the following fall in the Kawich Peak area about 120.9 km (75 mi.) northwest of the study area. The makeup of the deer herds on the NTS is quite different from that of deer in offsite areas. The large buck population indicates that an aged pristine herd exists on the NTS. In general, it should be noted that the deer populations are tied to the available water sources, although a vast area of excellent deer range is present but unavailable to the deer because of the lack of available water sources. This range condition has been maintained because of the periodic changes of available water due to construction activity, therefore resulting in a browsing rest rotation system. (Authors) *Keywords:* EPA*, mammal*, ecology/ecosystem*

251 **GIST, C.S. 1967. Problems of sampling desert arthropods before and after a thermonuclear cratering test. Great Basin Naturalist 27: 26-35.**

An analysis of selected arthropods near ground zero was made before and after a large thermonuclear device at the Nevada Test Site (Project Sedan) was detonated. The study was restricted to species that could be sampled readily with sunken can traps and that were known to be well represented in the test area. Possible changes in species composition or in relative abundance of species as a result of the test were sought. It was concluded that the only significant lesson that emerged from the above experience was that deducing real changes in arthropod populations on the basis of captures in traps was difficult and required a considerable sampling effort in order to avoid ascribing significance to differences that occurred simply due to chance. Species captured in the study were scorpions: *Vejovis confusus* Stahnke, *Hadrurus hirsutus* Wood; insects: *Areniva apacha* (Saussure), *Stenopelmatus fuscus* Thomas, *Ceuthophilus* spp., *Trogloderus costatus* LeConte, *Eleodes hispilabris* (Say), *Pelecyphorus pantex* Casey, and *Eleodes* spp. (mostly *E. armata* [LeConte]). (BSL) *Keywords:* perturbations*, invertebrate*, ecology/ecosystem*, radiation*

252 **GLENDENING, J.W. 1979. Aeolian Transport and Vegetative Capture of Particulates. Atmospheric Science No. 310, Department of Atmospheric Science, Colorado State University, Fort Collins, CO. UCRL–15092 - Pt.2.**

Aeolian (wind-blown) transport of soil particles to which plutonium is attached is responsible for the escape radioactivity beyond the boundaries of the Nevada Test Site. This thesis concerns the horizontal aeolian erosion of the large particles, which travel close to the ground. They are captured by desert creosote bushes, building radioactive wind hummocks around the shrub bases. The airflow above and below the average shrub height and inside a bush is investigated. The drag coefficient above the vegetation is found to decrease with increasing wind speed. Below the shrub height, the development of an internal boundary layer results in a logarithmic velocity profile. The bushes are widely spaced and aerodynamically very porous, producing a flow more typical of individual roughness elements than of a plant canopy. Partitioning the total drag above the vegetation into ground drag and bush drag contributions illustrates the dominant role of the vegetation in producing drag and thereby controlling soil erosion. The yearly horizontal erosion flux below bush height is estimated to be 40 grams per year per cm width, based upon monthly wind and soil moisture data and field erosion measurements. The ground stress needed to initiate movement is close to the minimum stress determined by Bagnold. Under these low erosion conditions the bush hummocks cannot grow large enough to significantly affect the ground stress inside the bush, so the limit to hummock growth is the creosote bush life span. It is concluded that the larger eroding particles are trapped by the bushes as they build hummocks, thus this mode of radioactive transport is negligible compared to the resuspension transport. (Author) *Keywords:* radionuclide inventory*, vegetation*, radiation*

253 **GOATES, M.A. 1963. Mites on kangaroo rats at the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 3(4), 12 pp.**

A systematic study of parasitic mites on kangaroo rats of two species at the Nevada Test Site was conducted from August 1959 to December 1961. The intent was to determine the kinds, numbers, seasonal occurrences and ecological relationships of mites in nuclear disturbed and contiguous undisturbed areas. A total of 1,256 rats from nine plant communities was examined. The 6,208 mites collected represented 16 species including four undescribed. Fourteen were found on both kinds of rats. Considerably more rats were infested with chiggers than with mesostigmatids. Seasonal peaks in numbers of mites occurred during the three periods of February-March, July, and October-November. Forty percent fewer rats in the nuclear disturbed areas were infested than in undisturbed areas, and only one-third as many mites were found on rats in the disturbed as in the undisturbed areas. (Author) *Keywords:* perturbations*, vegetation*, invertebrate*, mammal*, ecology/ecosystem*, radiation*

254 **GONZALEZ, D.A., B.F. EUBANK, Y.K. LEE, C.S. SOONG, and R.J. STRAIGHT. 1989. Onsite Environmental Report for the Nevada Test Site (January 1988 Through December 1988). DOE/NV/10630-8. Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, 244 pp.**

This report documents environmental monitoring at the Nevada Test Site (NTS) as conducted by the Department of Energy (DOE) onsite radiological safety contractor from January 1988 through December 1988. It presents results and evaluations of radiological and non-radiological measurements in air and water, and of direct gamma radiation exposure rates. Moreover, it presents relevant comparisons between the data recorded, DOE concentration guides (CG's) and applicable standards. The radiological monitoring results for CY1988 reveal that the concentrations of radionuclides in air and water on the

Nevada Test Site were far below the allowable limits set forth in the DOE guidelines. The highest average gross beta concentration in air was 0.002 percent of the DOE derived concentration guide (DCG). This concentration is considered close to background for the NTS. The highest average ^{239}Pu concentration is air was 23 percent of the DCG. The highest average tritium concentration in air was 0.04 percent of the DCG. ^{85}Kr concentrations compared favorably to the offsite average and to worldwide concentrations. All ^{133}Xe positive results were associated with specific events. Both ^{85}Kr and ^{133}Xe concentrations were far below the allowable limits. The highest average gross betas concentration in potable water was well within the allowed CG. Tritium and ^{239}Pu levels were, for the majority, below detection levels and is all cases, below CG's. Contaminated waters contained measurable amounts of tritium and some ^{239}Pu. Effluent measurements were maintained and reported to the DOE. The reported estimates of total curies released into the environment are listed in the chapter titled Effluent Monitoring. External gamma rates were consistent with data obtained from years past. Drinking water and air pollution permits were obtained and maintained during CY-1988 as part of the continual monitoring of non-radiological substances. Dose results to workers performing light activity work at stations possessing maximum concentration averages were calculated and the data indicated that minimum doses were obtained as the result of NTS activities. (Authors) *Keywords:* radionuclide inventory*, mammal*, radiation*

255 GONZALEZ, D.D., C.T. WARREN, and C.L. WASHINGTON. 1973. Water levels and spring discharges for selected wells and springs in Nevada, 1966-69. USGS-474-171, 69 pp.

Surface-water and ground-water data are collected from selected wells and springs in Nevada. Data presented are for the period 1966-69 and were collected from ground-water wells, gaging stations, miscellaneous sites, and four hot spring sites. A brief description of location of measurement sites is given. The data collection network is to evaluate possible effects of nuclear explosions on the hydrology of springs and wells. (Authors) *Keywords:* perturbations*, hydrology*, wetlands*

256 GOODWIN, R.G., J.M. MUELLER, and K.R. RAUTENSTRAUCH. 1995. Survival, Movements, and Burrow Use of Hatchling Desert Tortoises at Yucca Mountain, Nevada. In: The Desert Tortoise Council Proceedings of 1995 Symposium, p. 70. Desert Tortoise Council, Inc., San Bernadino, CA.

We radiomarked hatchling desert tortoises (*Gopherus agassizii*) at Yucca Mountain as they emerged from their nests and monitored them until they entered their hibernacula during 1992-994 to determine survival rates, movement patterns, and burrow use. We located hatchlings an average of two times/week in 1992 and three times/week in 1993 and 1994. We determined location coordinates by measuring the bearing and distance to the nest or to a burrow previously used by the hatchling. Survival rates to first hibernation were 30% in 1992 (n=20), 74% in 1993 (n=19), and 75% in 1994 (n=20). Several hatchlings were killed by desert fire ants (Solenopsis spp.); no avian predation was documented. Hatchlings were located on consecutive days (n=621) to determine the distance moved in one day. When hatchlings moved (n=346), they were found an average of 9 m (range= 1-144 m) from their previous location. Hibernacula were an average of 107 m (n = 34, SD= 117, range = 5-461 m) from the nest. Hatchlings used an average of 5.4 (n = 34, SD = 2.6, range= 1-11) burrows, of which, 16% were excavated by the hatchlings, 49 were rodent burrows, 24% were natural cavities, 1% were excavated by other tortoises, and 10% were of unknown origin. (Authors) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*

257 GRABSKE, R.J., and J. M. DAWSON. 1969. Ecological studies at far-out locations. In: Bio-Medical Division Preliminary Report for Project Schooner (USAEC Report UCRL-50718), pp. 70-71.

The Schooner Event was a 31-kiloton nuclear cratering detonation executed on 8 December 1968 at the Nevada Test Site. The Bio-Medical Division participated in this event in a variety of ways concerned with prediction, transport, and interaction with the biosphere. The predictive effort considered those radionuclides created within the device and its environment with the aim of identifying those with the greatest biological hazard. During and immediately following the event a variety of field experiments were conducted. Aircraft samples of the cloud were analyzed to determine radionuclide and mass partitioning as a function of particle size and class. Fourteen sequential air-sampling stations were fielded to study the distribution and redistribution of airborne particulates up to 6 weeks following the event. Considerable redistribution of debris was found, with the stations initially upwind recording very high activity four days after detonation. Pigs were stationed at four sites in the field for studies of the fate of radionuclides inhaled and ingested under field conditions. Fallout trays and tritium sniffers were fielded to document the mass deposition and radionuclide specific activity of fallout material and the tritium content of the basesurge cloud. In a joint project with Plowshare Division, more than 300 parachute-borne air samplers were dropped through the cloud to determine the total cloud burden. Two high-volume debris separators and collectors were fielded to collect large amounts of debris from the base-surge cloud for laboratory experiments on the biological availability of radionuclides in fallout debris. Several additional field and laboratory experiments were begun after detonation. With debris collected from the base-surge cloud as well as with crater-lip material, experimenters are determining the biological availability of radionuclides to pigs, cows, and various aquatic organisms. The leachability of debris radionuclides is being determined in a variety of solvents, and the biological availability of the nuclides to aquatic animals is being assessed. An ecology program was begun in the immediate vicinity to study the half-residence-times of radionuclides in soils, plants, and animal life. Surveys of the residual soil contamination and in situ biological availability of radionuclides are also being conducted at distances 50 miles from ground zero. Many of these experiments are continuing projects. This report summarizes preliminary findings and indicates the direction of continuing efforts. (Authors) *Keywords:* perturbations*, radionuclide inventory*, vegetation*, invertebrate*, vertebrate*, mammal*, radiation*

258 GREEN, R.A. 1996. Yucca Mountain Biological Resources Monitoring Program Progress Report, January 1995 - December 1995. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5700-00001 Rev 00. Las Vegas, NV, 28 pp.

This report discusses the progress of the terrestrial ecosystem component of the Yucca Mountain Site Characterization Project (YMP): Site Characterization Effects Program (SCEP). Results of studies conducted from January 1995 through December 1995 for seven program areas are presented. These seven program areas include: Desert Tortoises (*Gopherus agassizii*), Habitat Reclamation, Monitoring and Mitigation, Radiological Monitoring, Biological Support, and Thermal Loading Studies. (CAW) *Keywords:* YMSCO*, perturbations*, desert tortoise*, vegetation*, ecology/ecosystem*, revegetation*

259 GREEN, R.A., J.L. BOONE, and C.L. SOWELL. 1997. Abundance and Species Composition of Rodent Populations at Yucca Mountain, Nevada. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00034 Rev 00. Las Vegas, NV, 12 pp.

The objective of this study was to determine the abundance and distribution of desert rodents in the Mojave-Great Basin Desert transition at Yucca Mountain, Nevada. The authors found D. *merriami* in relatively high abundance in all areas. *Chaetodipus formosus* was common and widely distributed except in the sandy valley bottoms where *Perognathus longimembris* was most abundant. *Neotoma lepida* and *P. crinitus* were most common at higher elevations. The relative abundance of species differed somewhat from what might be expected from previous studies, and the authors compare their trapping results with results from other small mammal studies on the NTS. A single *Mus musculus* was trapped in *Larrea-Lycium-Grayia* habitat, a species not previously reported from the NTS. The paucity of *Thomomys bottae* records onsite probably reflects the lack of appropriate trapping techniques for this species. This species did not appear to be uncommon in the Yucca Mountain area, as evidence of their presence (i.e., mounds of soil) was noted in many areas on and around Yucca Mountain, and several skulls were observed in owl pellets. The number of *A. leucurus* reported on these plots is likely an underestimate. Differences observed in rodent populations may reflect differences in plant species composition among sites designated with the same vegetation association name. Populations of all species examined fluctuated widely over the time period considered. In most cases, populations on plots within vegetation associations tracked one another closely. However, some species fluctuated asynchronously with other species. Additionally, the distribution of animals on individual study plots often was not uniform. These observations, combined with the differences in species composition among studies, suggest that animals in the transition zone also perceive the environment at a scale finer than that at which habitat types were defined; or that the ecological linkages between habitat type and species composition, as well as the linkage between habitat type and relative abundance, are loose. (CAW) *Keywords:* YMSCO*, vegetation*, mammal*, ecology/ecosystem*

260 GREEN, R.A., M.K. COX, T.B. DOERR, T.P. O'FARRELL, W.K. OSTLER, K.R. RAUTENSTRAUCH, and C.A. WILLS. 1991. Assessing Impacts on Biological Resources from Site Characterization Activities on the Yucca Mountain Project. In: Proceedings of the Second Annual International Conference, High Level Radioactive Waste Management. Las Vegas. American Society of Civil Engineers, New York, NY, American Nuclear Society, Inc., La Grange Park, IL, pp. 1456-1460.

An integrated impact assessment program was developed to monitor the possible effects of Site Characterization Activities on the biological resources of the Yucca Mountain area. The program uses control and treatment sites incorporating both spatial and temporal controls. The selection of biotic variables for monitoring was based on their relative importance in the ecosystem and their ability to provide information on potential impacts. All measures of biotic and abiotic variables will be made on the same sample plots to permit linking changes in variables to each other. (Authors) *Keywords:* YMSCO*, perturbations*, vegetation*, vertebrate*, ecology/ecosystem*

261 **GREGER, P. 1994. Status of Large Mammals and Birds on the Nevada Test Site in 1993. In: Status of the Flora and Fauna on the Nevada Test Site, 1993. Hunter, R.B. (Compiler), DOE/NV/11432-162, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 124-149.**

Primary monitoring efforts during 1993 involved surveys to assess trends of feral horses, mule deer, raptors, and ravens. Some additional work examined bird use of a newly constructed sewage pond and described the resident bird community. The feral horse population at the NTS is small, appears to be stable, unlike many other populations in the west which are expanding. Mule deer numbers appear to show no significant trends over the last five years. Raptor sighting rates showed differences with location and season during 1993. Raptor abundance was good during 1993, with many sightings of hatchling-year birds. (Author) *Keywords:* bird*, mammal*, ecology/ecosystem*

262 **GREGER, P. 1995. Status of Horses, Deer, and Birds on the Nevada Test Site, 1994. In: Status of the Flora and Fauna on the Nevada Test Site, 1994. Hunter, R.B. (Compiler), DOE/NV/11432-195, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 149-182.**

Surveys were conducted to assess trends of feral horses, mule deer, and raptors on the NTS. The feral horse population numbered 56 animals in 1994, a 14% decline over the past two years, and appeared to be controlled by mountain lion predation. The mean sighting rate of mule deer was 50% of the 1993 level, suggesting mule deer were less abundant on the NTS. Sighting rates suggest that raptors are more abundant on Yucca Flat than Frenchman Flat. Relative abundance of raptors on Yucca Flat was at least double or greater in spring and summer in 1994 over 1993, while on Frenchman Flat abundance was similar between years. Known locations of ravens nests were visited to record reproductive use. Raptors and ravens appear to be benefitting from the use of man-made structures on the NTS. (Author) *Keywords:* bird*, mammal*, ecology/ecosystem*

263 **GREGER, P., and E. ROMNEY. 1994. Feral Horse Monitoring at the Nevada Test Site From 1989-91. In: Status of the Flora and Fauna on the Nevada Test Site, 1989-91. Hunter, R.B. (Compiler), DOE/NV/11432-57, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 141-169.**

Monitoring of a small feral horse population at the Nevada Test Site was conducted from 1989 through 1991. During three years of monitoring, the total umber of horses (yearling and older) increased from 60 to 65 individuals. The number of adults in the population (3 years and older) stayed nearly constant at about 59 horses. Thirteen foals were missing during 1990-91. Mountain lion predation on foals appeared to be significant on the NTS, probably controlling the growth rate of the herd. (Authors) *Keywords:* mammal*, ecology/ecosystem*

264 **GREGER, P., and E. ROMNEY. 1994. Status of Large Mammals and Birds on the Nevada Test Site, 1992. In: Status of the Flora and Fauna on the Nevada Test Site, 1992. Hunter, R.B. (Compiler), DOE/NV/11432-58, Reynolds Electrical Engineering Co., Inc., Las Vegas, NV, pp. 144-175.**

Wildlife monitoring during 1992 included work on the feral horse population at the Nevada Test Site as well as observations on raptors and other migratory birds. The number of adults in the horse population (3 years and older) stayed nearly constant at fifty nine horses. The drought eased in 1992, resulting in an increased number of foals produced (seventeen), but foal losses increased to 100%. Mountain lion predation on foals was postulated to be controlling growth rate of the herd. A maximum population size of 80 horses for the NTS is recommended to minimize habitat disturbance. Increased frequencies of sightings of deer, raptors and other birds occurred during 1992 over 1991 suggesting a population response to the increased moisture availability. (Authors) *Keywords:* bird*, mammal*, ecology/ecosystem*

265 **GREGER, P., and E. ROMNEY. 1994. Trends in Wildlife Utilization of Water Sources and Adjacent Habitats at the Nevada Test Site, 1989-91. In: Status of the Flora and Fauna on the Nevada Test Site, 1989-91. Hunter, R.B. (Compiler), DOE/NV/11432-57, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 170-235.**

This report summarizes three years of qualitative field observations of wildlife during a drought in the Mojave desert. The Nevada Test Site, located on a portion of the Pacific flyway, is a natural stopping point for more than 100 common species of migratory birds. More than 20 man-made well reservoirs were biologically valuable, offering forage and resting habitat for thousands of individual birds during each migratory season. Quarterly counts of large granivorous species of birds at springs and well reservoirs indicated that mourning doves had recovered from initial drought effects but Gambel's quail had not. Other numerically important birds such as ravens have benefitted from the presence of man, including nesting in man-made structures, and from foraging in landfills and sewage lagoons. Local knowledge of birds at the NTS was limited due to lack of long-term monitoring over the last 20 years. Only 36 species of birds out of about 220 known from the region have been documented as breeders. Three years of casual observations of raptors suggest that red-tailed hawks are the most common species observed. Two species, the Ferruginous hawk and Swainson's hawk, conspicuous by their absence, may have suffered regional declines in numbers. Night spotlighting surveys of mule deer provided evidence that the population has declined during the drought. Significant losses of feral horse foals were consistent with mountain lion predation. The reduction in deer numbers available as prey during the drought may be a factor allowing predation on alternate prey, such as horses. (Authors) *Keywords:* wetlands*, bird*, mammal*, ecology/ecosystem*

266 GREGER, P.D., and E.M. ROMNEY. 1999. High Foal Mortality Limits Growth of a Desert Feral Horse Population in Nevada. Great Basin Naturalist 59(4):374-379.

A population of feral horses (*Equus caballus*) in the southern Great Basin Desert of Nevada was monitored from 1989 to 1998 to determine size, distribution, and population trends. All individual horses observed in the population were identified by unique markings during the first 2 yr of study, and most animals could be observed annually. During this study no new horses were identified in the population, indicating that no immigration occurred from outside populations. The population reached a high of 65 horses yearling or older in 1992 and declined each year thereafter, reaching a low of 36 horses in 1998. Estimated foal survival averaged <12% over 8 yr. Only 11 horses were recruited into the population as yearlings or older animals during the study. Mountain lion predation is hypothesized as a major factor limiting growth of this feral horse population. (Authors) *Keywords:* mammal*, ecology/ecosystem*, life history*

267 GROVER, M.C., and L.A. DEFALCO. 1995. Desert Tortoise (*Gopherus agassizii*): Status-of-Knowledge, Outline with References. FSGTR/INT-316 , Intermountain Research Station, U.S. Forest Service, Ogden, UT, 139 pp.

The report provides an overview of extant desert tortoise literature, summarizing literature on taxonomy, morphology, genetics, and paleontology and paleoecology of the desert tortoise as well as its general ecology. Literature on desert tortoise ecology encompasses distribution and habitat, burrows and dens, reproduction, growth, physiology, feeding and nutrition, mortality factors, and behavior. Information on habitat deterioration, management of tortoises, their legal status and tortoise husbandry is also included. It is a complete overview of existing literature, including peer-reviewed literature and other literature. Information was compiled from materials available in 1991. (Authors) *Keywords:* desert tortoise*, ecology/ecosystem*, life history, physiology*, nutrition/diet*

268 HALDEMAN, D.L., and P.S. AMY. 1993. Bacterial heterogeneity in deep subsurface tunnels at Rainier Mesa, Nevada Test Site. Microbial Ecology 25:183-194.

To characterize the deep subsurface environment of Rainier Mesa, Nevada Test Site, rock samples were taken from tunnels U12b, U12g, U12p, and U12n, which varied in depth from 50 m to 450 m and in gravimetric moisture content from 4% to 27%. Values for total count, viable count, biomass, Simpson diversity, equitability, similarity coefficient, and number of distinct colony types indicated microbiological variability between samples. Viable counts ranged from less than 1×10^1 to 2.4×10^5 CFU g dry wt^{-1} of rock. Direct counts and enumeration based on phospholipid determination indicated larger numbers of cells g dry wt^{-1} of rock than viable counts. Simpson diversity indices, equitability, and numbers of distinct colony types varied from 3.00 to 8.05, 0.21 to 0.89, and 7 to 19, respectively, and indicated heterogeneity between samples. Each distinct morphotype was purified and characterized. Gram reaction, morphology, metal and antibiotic resistances, and metabolic activities of each isolate confirmed spatial variability among microbiota isolated from different locations. Most probable numbers of nitrifying, sulfur oxidizing, and sulfur-reducing bacteria were below the limit of detection in all samples, while the numbers of nitrogen fixing bacteria ranged from below the level of detection to 7.8×10^2 cells g dry wt^{-1} of rock sample, and the numbers of denitrifying bacteria ranged from below the level of detection to greater than 1.6×10^3 cells g dry wt^{-1} of rock sample. (Authors) *Keywords:* geology*, microbiota*, physiology*, ecology/ecosystem*

269 **HALDEMAN, D.L., and P.S. AMY. 1993. Diversity within a colony morphotype: implications for ecological research. Applied and Environmental Microbiology 59(3):933-935.**

Sets of bacterial isolates with the same colony morphologies were selected from spread plates of bacteria from deep subsurface rock samples; each set had a unique morphology. API-rapid-NFT analysis revealed that isolates within a set were the same. Fatty acid methyl ester analysis of one set of isolates clustered organisms within the same species, defining variation between isolates at the biotype (subspecies) and strain levels. Metal resistances consistently tracked with colony morphology, while antibiotic resistances were less reliable. (Authors) *Keywords:* geology*, microbiota*, methods*, ecology/ecosystem*

270 **HALDEMAN, D.L., L. RAGATZ, and P.S. AMY. 1996. Distribution and Nutrient Limitations of Heterotrophic Bacteria from Yucca Mountain. In: *High Level Radioactive Waste Management*, Proceedings of the Seventh Annual International Conference, Las Vegas, NV, April 29 - May 3, 1996, pp. 30-32. American Nuclear Society; American Society of Civil Engineers, La Grange Park, IL.**

The aims of this research were to (1) gather background data concerning the numbers and distribution of bacteria indigenous to Yucca Mountain, (2) determine nutrient limitations of indigenous bacteria, and (3) collect isolates for further investigation. (Authors) *Keywords:* YMSCO*, microbiota*, nutrition/diet*, ecology/ecosystem*

271 **HALDEMAN, D.L., P.S. AMY, D. RINGELBERG, and D.C. WHITE. 1993. Characterization of the microbiology within a 21 m^3 section of rock from the deep subsurface. Microbial Ecology 26:145-159.**

The distribution of aerobic chemoheterotrophic microorganisms within a 21 m^3 section of deep subsurface rock was determined. Nineteen samples for microbiological analysis were aseptically taken by hand from the walls of a 400 m deep subsurface tunnel after an alpine miner created fresh rock faces 0.76, 1.52, 2.28, and 3.04 m into the tunnel wall. The direct counts were several orders of magnitude greater than viable counts in all samples. One of each morphologically distinct bacterial type from each sample was purified and analyzed for fatty acid methyl esters (FAME) using the Microbial Identification System (MIDI). Numbers of bacterial types, diversity, and equitability of recoverable microbial communities were the same or similar using either morphotype or FAME analyses as the basis for distinguishing between bacterial types. Twenty-nine genera (Euclidean distance of $\leq$25) were found within the rock section, while 28 of the 210 bacterial types isolated were nonculturable under the growth regime required for cluster analysis. Most isolates clustered at the genus level with *Arthrobacter, Gordona*, and *Acinetobacter*. Two genera, containing 16 isolates, were unmatched to known organisms within the MIDI data base and clustered with other isolates at a Euclidean distance greater than 50. While some species (Euclidean distance $\leq$10) were recovered from multiple sites within the rock section, most were found at 1-3 sites and usually without a definitive pattern of distribution. (Authors) *Keywords:* geology*, microbiota*, ecology/ecosystem*, methods*

272 **HALDEMAN, D.L., P.S. AMY, D.C. WHITE, and D.B. RINGELBERG. 1994. Changes in bacteria recoverable from subsurface volcanic rock samples during storage at 4°C. Applied and Environmental Microbiology 60(8):2697-2703.**

The abundance of viable microorganisms recovered from deep subsurface volcanic rock samples increased after rock perturbation and storage for 1 week at 4°C, while the diversity and evenness of recoverable heterotrophic bacterial communities generally decreased. One sample of each morphologically distinct colony type, recovered both before and after storage of U12n rock samples, was purified and characterized by fatty acid methyl ester (MIDI) and API rapid NFT strips. As determined by MIDI cluster analysis, the composition of the recoverable microbial communities changed with storage of rock samples; some groups of organisms were recovered only before, only after, or at both sample times. In general, the isolates recovered only after storage of rock samples had a greater ability to utilize the carbohydrates included in API test strips and had faster generation times than isolates recovered only on initial plating. The nutritional versatility and faster growth rates of organisms recovered in higher proportions after sample storage provide evidence that some microbial community changes may be due to the proliferation of a few bacterial types. However, because some new genera are recovered only after storage, the possibility also exists that dormant bacterial types are resuscitated during sample perturbation and storage. (Authors) *Keywords:* geology*, perturbations*, microbiota*, physiology*, methods*, ecology/ecosystem*

273 **HALDEMAN, D.L., B.J. PITONZO, S.P. STORY, and P.S. AMY. 1994. Comparison of the microbiota recovered from surface and deep subsurface rock, water, and soil along an elevational gradient. Geomicrobiology Journal 12:99-111.**

The isolation of viable microorganisms from deep volcanic rock formations (50-450 m) within Rainier Mesa, Nevada Test Site has posed questions regarding the origin of in situ bacteria. One hypothesis under investigation is that microbial transport to depth has been facilitated via recent natural water flow from surface bacterial populations. Recoverable microbiota from surface topsoil, paleosol, rock, and outflow spring water were compared to those from subsurface rock and fracture flow water to determine if relationships existed between microbial communities along an elevational gradient. Direct counts were higher than culturable counts in all samples. Topsoil samples had higher culturable counts and numbers of nitrogen-fixing and sulfur-reducing bacteria than samples from the subsurface rock. Heterogeneity in microbial communities from the different samples (measured by diversity and evenness indices and by comparison of morphological and physiological tests of representative isolates) was demonstrated and provided evidence against the hypothesis for recent bacterial transport from the surface. An alternative hypothesis, that bacterial communities in deep subsurface rock have been isolated from surface environments for long periods of time, is discussed. (Authors) *Keywords:* geology*, hydrology*, wetlands*, microbiota*, ecology/ecosystem*

274 HALEY, T.J. 1964. Experimental usefulness of the kangaroo rat. Laboratory Animal Care 14:95-102.

Specialized research problems have resulted in the introduction of new and often exotic species of animals into the research laboratory. The kangaroo rat is one example of such an introduction. This readily tamed and useful animal has certain characteristics which make it unique and of interest in highly specialized research programs. Studies have been conducted on its ability to exist on a dried diet with only a bare minimum of water and that obtained from succulent plants. Hematological studies indicate that the kangaroo rat exhibits a different hematological distribution of cells than the mouse or rat. The lymphocyte constitutes 81.4% of the total leukocytes. The hematocrit has a value of 46 to 48 in spite of the high degree of water conservation practiced by the animal. The response to ionizing radiation of this species does not differ from that reported for the mouse or rat. Behavior studies indicate that digging characteristics of the kangaroo rat are similar to those of the gerbil. Furthermore, the animal shows definite psychotic tendencies under the influence of psychotomimetics like LSD-25 and psilocybin. At present an evaluation of the physiological responses of isolated tissues from this animal as well as its responses to anesthetics is being undertaken to evaluate its further usefulness in the laboratory. *Keywords:* vegetation*, mammal*, physiology*, nutrition/diet*, radiation*, methods*

275 HALEY, T.J., R.G. LINDBERG, A.M. FLESHER, K. RAYMOND, W. McKIBBEN, and P. HAYDEN. 1960. Response of the kangaroo rat (*Dipodomys merriami* Mearns) to single wholebody x-irradiation. Radiation Research 12:103-111.

The responses of the kangaroo rat (*Dipodomys merriami* Mearns) to single whole-body x-irradiation in the dosage range 25 to 550 r have been studied. The ST_{50} of this species at 550 r was 10.3 (9.7 to 10.9) days, which is almost identical with that of the CF-1 mouse. Observations were made of the following: total erythrocytes, total leukocytes, differential cell count, platelets, hemoglobin, hematocrit, bone marrow, and adrenal, kidney, spleen, and body weights. The responses of the kangaroo rat were essentially the same as those observed in the albino rat, but the general symptomatology was different, reflecting, in part, the difference in intestinal flora. In the nonirradiated kangaroo rat, the lymphocyte comprises 81.4% of the total leukocytes, and the spleen has an average weight of only 33 ± 2.88 mg. (Authors) *Keywords:* microbiota*, mammal*, physiology*, radiation*

276 HALL, D. 2000. Bat Monitoring on the Nevada Test Site in South-Central Nevada. 2000 Transactions of the Western Section of the Wildlife Society 36:8-14. Bechtel Nevada, Las Vegas, NV.

The Nevada Test Site (NTS) is located in south-central Nevada and encompasses approximately 3,561 square kilometers. It straddles both the Mojave and Great Basin Deserts and includes a distinct transition region between these two deserts. Because of its size and geographical location, a great deal of vegetative and physiographic diversity exists on the NTS. This diversity of habitat allows for a diverse mix of bat species to exist on the NTS. Numerous mines and tunnels occur on the NTS, which are potential roost sites for bats. Several man-made and natural water sources also occur throughout the NTS. Multiple techniques have been used to inventory and monitor the bat fauna on the NTS. These techniques have included mistnetting at water sources with and without concurrent acoustic sampling, acoustic road surveys, and acoustic sampling at mine and tunnel entrances. To date, a total of 14 species of bats has been documented on the NTS, of which seven are considered species of concern by the U.S. Fish and Wildlife Service. These include Townsend's big-eared bat (*Corynorhinus townsendii*), spotted bat (*Euderma maculatum*), small-footed myotis (*Myotis ciliolabrum*), long-eared myotis (*M. evotis*), fringed myotis (*M. thysanodes*), long-legged myotis (*M. volans*), and big free-tailed bat (*Nyctinomops macrotis*). The Townsend's big-eared bat, spotted bat, long-eared myotis, and big free-tailed bat have been found exclusively in the Great Basin Desert ecoregion, and bat species richness was highest in this region based on mistnet and acoustic surveys. The small-footed and long-legged myotis were found throughout the NTS, and the fringed myotis was found in the Mojave and Great Basin Desert ecoregions but is likely to be found in the transition ecoregion as well. The small footed myotis, long-legged myotis. and western pipistrelle were the most frequently detected species in the Great Basin Desert ecoregion. The western pipistrelle and California myotis were the most frequently detected species in the transition ecoregion, while the western pipistrelle, *California myotis*, and pallid bat were the most frequently detected species in the Mojave Desert ecoregion. Acoustic sampling using the Anabat II system has greatly facilitated the monitoring of bats on the NTS, and allowed biologists to cost-effectively survey large areas for bat activity. (Author) *Keywords:* sensitive animals*, wetlands*, mammal*, ecology/ecosystem*, methods*

277 HALL, P.F., B.W. SCHULTZ, J.P. ANGERER, and W.K. OSTLER. 1993. The influence of annual species composition and density on perennial seedling density in four plant communities in the northern Mojave Desert. CONF-9310276–1, EGG 11265-2030, EG&G Energy Measurements, Environmental Sciences Department, Las Vegas, NV.

According to the Nuclear Waste Policy Act of 1982 (as amended in 1987), the U.S. Department of Energy (DOE) must study and characterize Yucca Mountain as a potential site for long-term underground storage of high-level nuclear waste. Part of the overall site characterization program is to monitor potential impacts on the biological resources at Yucca Mountain. A part of the biological monitoring program, assessed vegetation parameters included density of annual and perennial seedlings. This data was used to evaluate: (1) seed germination and seed survival; and (2) if annual plant species density and cover influence perennial seedling survival. Twelve permanent 200 x 200-m study plots were established in each of four vegetation associations present in the Yucca Mountain Project area. During the spring of 1992, 20 to 60, 1-m^2 randomly-located quadrants per study plot were measured for perennial seedling density, annual species density, and annual species composition. Perennial seedlings found in 1992 were relocated in the spring of 1993, and survival determined. Cover was measure in the spring of 1992. Annual plant density and cover was greatest in the *Larrea Lycium-Grayia* vegetation association, and lowest in the *Larrea-Ambrosia* vegetation association. Annual seedling density had a negative exponential relationship with perennial seedling density in 1992. However, non-linear regression analysis indicated that 1992 annual seedling density had a greater impact on survival of perennial seedlings from 1992 to 1993. (Authors) *Keywords:* YMSCO*, vegetation*, annual plants*, perennial plants*, ecology/ecosystem*, life history*

278 HAMERLYNCK, E.P., T.E. HUXMAN, M.E. LOIK, and S.D. SMITH. 2000. Effects of extreme high temperature, drought and elevated CO_2 on photosynthesis of *Larrea tridentata*, a Mojave Desert evergreen. Plant Ecology 148:185-195.

The interaction of extreme temperature events with future atmospheric CO_2 concentrations may have strong impacts on physiological performance of desert shrub seedlings, which during the critical establishment phase often endure temperature extremes in conjunction with pronounced drought. To evaluate the interaction of drought and CO_2 on photosynthesis during heat stress, one-year-old *Larrea tridentata* [DC] Cov. seedlings were exposed to nine days of heat with midday air temperature maxima reaching 53°C under three atmospheric CO_2 concentrations (360, 550 and 700 µmol mol^{-1}) and two water regimes (well-watered and droughted). Photosynthetic gas exchange, chlorophyll fluorescence and water potential responses were measured prior to, during and one week following the high temperature stress event. Heat stress markedly decreased net photosynthetic rate (A_{net}), stomatal conductance (g_s), and the photochemical efficiency of photosystem II (F_v/F_m) in all plants except for well-watered *L. tridentata* grown in 700 µmol mol^{-1} CO_2. A_{net} and g_s remained similar to pre-stress levels in these plants. In droughted *L. tridentata*, A_{net} was ca. 2 x (in 550 µmol mol^{-1} CO_2) to 3 x (in 700 µmol mol^{-1} CO_2) higher than in ambient-CO_2-grown plants, while g_s and F_v/F_m were similar and low in all CO_2 treatments. Following heat stress, g_s in all well-watered plants rose dramatically, exceeding pre-stress levels by up to 100%. In droughted plants, g_s and A_{net} rose only in plants grown at elevated CO_2 following release from heat. This recovery response was strongest at 700 µmol mol^{-1} CO_2, which returned to A_{net} and g_s values similar to pre-heat following several days of recovery. Extreme heat diminished the photosynthetic down-regulation response to growth at elevated CO_2 under well-watered conditions, similar to the action of drought. Ambient-CO_2-grown *L. tridentata* did not show significant recovery of photosynthetic capacity (A_{max} and CE) after alleviation of temperature stress, especially when exposed to drought, while plants exposed to elevated CO_2 appeared to be unaffected. These findings suggest that elevated CO_2 could promote photosynthetic activity during critical periods of seedling establishment, and enhance the potential for *L. tridentata* to survive extreme high temperature events. (Authors) *Keywords:* FACE*, perturbations*, climate*, perennial plants*, physiology*

279 HAMERLYNCK, E.P., T.E. HUXMAN, R.S. NOWAK, S. REDAR, M.E. LOIK, D.N. JORDAN, S.F. ZITZER, J.S. COLEMAN, J.R. SEEMANN, and S.D. SMITH. 2000. Photosynthetic responses of *Larrea tridentata* to a step-increase in

atmospheric CO_2 at the Nevada Desert FACE Facility. Journal of Arid Environments 44:425-436.

Of all terrestrial ecosystems, the productivity of deserts has been suggested to be the most responsive to increasing atmospheric CO_2. The extent to which this prediction holds will depend in part on plant responses to elevated CO_2 under the highly variable conditions characteristic of arid regions. The photosynthetic responses of *Larrea tridentata*, an evergreen shrub, to a step-increase in atmospheric CO_2 (to 550 µmol mol^{-1} were examined in the field using Free-Air CO_2 Enrichment (FACE) under seasonally varying moisture conditions. Elevated CO_2 substantially increased net assimilation rate (A_{net}) in *Larrea* during both moist and dry periods of the potential growing season, while stomatal conductance (g_s,) did not differ between elevated and ambient CO_2 treatments. Seasonal and diurnal gas exchange dynamics in elevated CO_2 mirrored patterns in ambient CO_2, indicating that elevated CO_2 did not extend photosynthetic activity longer into the dry season or during more stressful times of the day. Net assimilation *vs*. internal CO_2 (A/C_i) responses showed no evidence of photosynthetic down-regulation during the dry season. In contrast, after significant autumn rains, A_{max} (the CO_2 saturated rate of photosynthesis) and CE (carboxylation efficiency) were lower in *Larrea* under elevated CO_2. *In situ* chlorophyll fluorescence estimation of *Larrea* Photosystem II efficiency (F_v/F_m) responded more to water limitation than to elevated CO_2. These findings suggest that predictions regarding desert plant responses to elevated CO_2 should account for seasonal patterns of photosynthetic regulatory responses, which may vary across species and plant functional types. (Authors) *Keywords:* FACE*, perturbations*, climate*, perennial plants*, physiology*

280 HANSEN, D.J., and W.K. OSTLER. 2001. Rooting Characteristics of Vegetation Near Areas 3 and 5 Radioactive Waste Management Sites at the Nevada Test Site. Bechtel Nevada, Las Vegas, NV. (In review).

The U.S. Department of Energy emplaced high-specific-activity low-level radioactive wastes and limited quantities of classified transuranic wastes in Greater Confinement Disposal (GCD) boreholes from 1984 to 1989 on the Nevada Test Site (NTS) in southern Nevada. The boreholes were backfilled with native alluvium soil. The surface of these boreholes is expected to be colonized by native vegetation in the future. Considering the long-term performance of the disposal facilities, bioturbation is considered a primary release mechanism for radionuclides disposed in GCD boreholes. This report provides information about rooting characteristics of vegetation near Areas 3 and 5 Radioactive Waste Management Sites (RWMS) of the NTS. Data from this report will be used to resolve uncertainties involving parameterization of models used to characterize the biotic mixing of soils and waste transport processes by biota. Objectives of this study were to: (1) survey the prior ecological literature on the NTS and identify pertinent information about the vegetation, (2) conduct limited field studies to describe the current vegetation in the vicinity Areas 3 and 5 RWMS so as to correlate findings with more extensive vegetation data collected at Yucca Mountain and the NTS, (3) review prior performance assessment documents and evaluate model assumptions based on current ecological information, and (4) identify data deficiencies and make recommendations for correcting such deficiencies. Historical and recent site observations of shrub rooting patterns on the NTS suggest that root depth rarely exceeds 2 meters although a few very deep (8 meters) individual roots have occasionally been observed during construction of the waste trenches. Most of the roots are confined to the near surface soil horizons and diminish with depth as soil moisture and plant nutrients correspondingly decrease. Reported findings of fossil packrat midden studies suggested that during the past 20,000 years annual temperatures may have been 6^0 C to 7^0 C cooler and precipitation 40 percent more than the climate currently. A possible return to these conditions within the next 10,000 years formed the basis for future scenarios which suggested that valley bottoms would be dominated by shrublands rather than woodlands. Measurements of the current vegetation were taken to describe plants in the vicinity of the RWMS such as plant structure and community composition. While no quantitative data exists for characterizing shrub roots in the vicinity of the RWMS, estimates of some root system parameters can be made for some species at some sites for future modeling efforts. These estimates are based on statistical correlations of measured plant structures to other plant parts or parameters to provide estimates of root biomass, maximum rooting depth, and annual biomass production. Findings developed in this study will assist future modeling efforts including those being conducted to evaluate the role of ants, termites, and burrowing animals. (Authors) *Keywords:* climate*, vegetation*, perennial plants*, mammal*, ecology/ecosystem*, methods*

281 HANSEN, D.J., P.D. GREGER, C.A. WILLS, and W.K. OSTLER. 1997. Nevada Test Site Wetlands Assessment. DOE/NV/11718-124. Bechtel Nevada, Las Vegas, NV, 161 pp.

Twenty-five natural sources of water on the U.S. Department of Energy's (DOE) Nevada Test Site (NTS) were visited from June 1996 through January 1997. These water sources included 15 springs, 5 seeps, 4 tank sites (natural rock depressions that catch and hold surface runoff), and 1 ephemeral playa pond. They are rare, localized habitats on the NTS that are important to regional wildlife and to isolated populations of water-tolerant plants and aquatic organisms. This report identifies 16 NTS natural water sources that may be classified as "jurisdictional wetlands" and eight that may be classified as "waters of the United States" regulated under the Clean Water Act of 1977. This report also identifies and summarizes previous studies of NTS natural water sources; describes the known physical, chemical, and biological features of these water sources; and identifies the current DOE management practices related to the protection of NTS wetlands. The 16 NTS water sources which met the criteria to be considered jurisdictional wetlands included Cane Spring, Captain Jack Spring, Cottonwood Spring, Coyote Spring, Gold Meadows Spring, John's Spring, Oak Spring, Reitmann Seep, Tippipah Spring, Topopah Spring, Twin Spring, Wahmonie Seep 1, Wahmonie Seep 2, Wahmonie Seep 3, Whiterock Spring, and the vegetated margins of Yucca Playa Pond. Lists of plants, algae, and wildlife by location are provided in tables. (Authors) (CAW) *Keywords:* management*, wetlands*, microbiota*, vegetation*, invertebrate*, bird*, reptile*, mammal*, ecology/ecosystem*

282 **HANSON, W.C. (Ed.) 1980. Transuranic Elements in the Environment - A Summary of Environmental Research on Transuranium Radionuclides Funded by the U.S. Department of Energy Through Calendar Year 1979. DOE/TIC-22800, Technical Information Center, U.S. Department of Energy.**

This report presents a plutonium-transport model, based on the results of other Nevada Applied Ecology Group plutonium studies. It is used to estimate potential chronic rates of ^{239}Pu inhalation and ingestion as functions of the average concentration of ^{239}Pu (C_S, picocuries per gram) in the surface soil (0- to 5-cm depth) of the reference area. A dose-estimation model, based on parameter values recommended in publications of the International Commission on Radiological Protection (ICRP), is used to estimate organ burdens, accumulated doses, and dose commitments as functions of exposure time. These estimates are combined with ICRP recommendations for allowable public exposure to radiation to arrive at acceptable soil concentrations at NTS. Also summarized in this report is contamination levels in soil from various NAEG study areas on the NTS and the dynamics of the contamination mechanisms in vegetation including foliar deposition and root uptake. (CAW) *Keywords:* NAEG*, vegetation*, vertebrate*, radiation*, methods*

283 **HASTRITER, M.W. 2000. *Jordanopsylla becki* (Siphonaptera: Ctenophthalmidae), a new species of flea from the Nevada Test Site. Proceedings of the Entomological Society of Washington 102 (1):135-141.**

Jordanopsylla becki, a new species of flea collected 1.25 km north of Mercury, Nevada Test Site, Nye County, Nevada, from *Neotoma lepida* is described and illustrated. This flea, assigned to the subfamily Anomiopsyllinae, tribe Jordanopsyllini, is a nest flea found as an adult only during the winter months. Techniques for recovering this rare flea are described. (Author) *Keywords:* invertebrate*, taxonomy*

284 **HATCH, F.T., E.J. RIDLEY, and J.A. MAZRIMAS. 1971. Some *Dipodomys* species: ecologic and taxonomic features, estrous cycle, and breeding attempts. USAEC Report UCRL-51140, 25 pp.**

A colony of various species of kangaroo rats (*Dipodomys*) was maintained to gain practical experience concerning their maintenance needs, especially nutrition and reproduction. Information is included on trapping experience, species identification, habitats on the Nevada Test Site, and breeding phenology. (TPO) *Keywords:* mammal*, life history*, nutrition/diet*, ecology/ecosystem*

285 **HATCH, F.T., J.A. MAZRIMAS, J.J. KORANDA, and J.R. MARTIN. 1970. Ecology and radiation exposure of kangaroo rats living in a tritiated environment. Radiation Research 44:97-107.**

Kangaroo rats *(Dipodomys ordii*) living near a crater resulting from a nuclear detonation were found to be generally tritiated. The tritium activity of body water and tissues ranged from 0.1 to 0.4 uCi per gram. Organically bound tissue tritium had approximately the same specific activity as body water (6 - 8 x 10^6 dpm per gram hydrogen). The animals appeared to be in equilibrium with their food supply and the soil, in terms of tritium concentrations. The lifetime chronic radiation dose to adult animals was estimated to be 10 rad from internal ^{3}H. About 10 rad was also received from persistent external β- and γ-emitting radionuclides in the soil. There was no significant concentration of other internal radionuclides. The generalized tritium labeling and chronic low-level radiation exposure are of special interest in these animals. There was no macroscopic evidence of harmful radiation effects. (Authors) *Keywords:* mammal*, radiation*

286 **HAYWARD, C.L., M.L. KILLPACK, and G.L. RICHARDS. 1963. Birds of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 3(1), 27 pp.**

Water sources, small as they are, are responsible for the presence of many species of birds at the Nevada Test Site. When natural vegetation was destroyed by atomic testing or construction, it was typically replaced within a short time by Russian thistle (*Salsola kali*). This weed serves as a source of food and cover for many small birds. (HP) *Keywords:* perturbations*, invasive species*, wetlands*, annual plants*, bird*, ecology/ecosystem*, nutrition/diet*, taxonomy*

287 HELVIE, J.B., and D.D. SMITH. 1971. Summary of necropsy findings in desert bighorn sheep. SWRHL-62r, 10 pp.

Necropsies were performed on 49 desert bighorn sheep. Incidence of pulmonary pathology was high for all age classes. The major cause of death, when determined, was pneumonia. (TPO) *Keywords:* EPA*, mammal*, physiology*

288 HERMAN, D.J., R.K. SCHULZ, R.M. ROMNEY, H. NISHITA, and A. WALLACE. 1980. Relative Adsorption and Plant Uptake of Plutonium 238 and Plutonium 239 in Soils. DOE/SF/00012-T12, University of California, Los Angeles, 11 pp.

Several investigators have observed differences of behavior between ^{238}Pu and ^{239}Pu in natural environments. Hakonson and Johnson (1973), working with Trinity Site samples, observed decreasing ^{239}Pu/ ^{238}Pu ratio from soil to vegetation to rodent indicating that ^{238}Pu was more mobile than ^{239}Pu. Little (1976) reported that ^{238}Pu was more mobile than ^{239}Pu in a grassland ecosystem in Colorado. Markham, Puphal, and Filer (1978), working in a transuranic waste disposal area at the Idaho National Engineering Laboratory Site obtained some data indicating that the downward migration of ^{238}Pu in the soil might be occurring at a faster rate than that observed for ^{239}Pu. The objective of the present investigations was to confirm the reportedly greater apparent solubility and mobility of ^{238}Pu to comparison to ^{239}Pu in the environment. This was pursued by plant uptake and chemical extraction experiments in the laboratory. (Authors) *Keywords:* vegetation*, mammal*, nutrition/diet*, radiation*

289 HERRIN, C.S., and D.E. BECK. 1965. Observations on the biology, anatomy, and morphology of *Otobius lagophilus* Cooley and Kohls. Brigham Young University Science Bulletin, Biological Series 6(2), 19 pp.

Summarizes present knowledge about the geographic distribution, seasonal occurrence, and host-parasite relationships of the soft-bodied tick *Otobius lagophilus* Cooley and Kohls in western North America, including the Nevada Test Site. The preferred host is *Lepus californicus* the black-tailed jackrabbit, although collections have been made on *Lepus townsendii* and *Sylvilagus* spp. The tick has been found to be naturally infected with Rocky Mountain spotted fever, Colorado tick fever, and tularemia. It is capable of harboring *Pasteurella tularensis* for as long as 676 days. *Otobius lagophilus* may be a potential reservoir of some diseases in nature, but not a direct vector in transmission from host to host. (TPO) *Keywords:* microbiota*, invertebrate*, mammal*, physiology*, ecology/ecosystem*

290 HERSMAN, L.E. 1996. Microbiological Sorption and Transport: Field and Laboratory Experiments. In: High Level Radioactive Waste Management: Proceedings of the Seventh Annual International Conference, Las Vegas, NV, April 29 - May 3, 1996, pp. 27-29. American Nuclear Society; American Society of Civil Engineers, La Grange Park, IL.

The purpose of the Microbiological Sorption and Transport Study is to estimate the effects of the indigenous microbial population on the transport of radioactive wastes away from the proposed site of the high-level nuclear repository, Yucca Mountain, NV. (Author) *Keywords:* microbiota*, radiation*

291 HESSING, M.B., and G.T. SHARP. 1998. Potential Impacts of Site Characterization Activities on Vegetation at Yucca Mountain, Nevada, 1995 - 1997. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00093 Rev 00 DRAFT A. Las Vegas, NV, 34 pp.

Yucca Mountain, Nevada, is being studied as a potential site for high-level nuclear waste burial. Vegetation was monitored for three years, from 1995 to 1997, to determine if intensive site characterization activities had an indirect impact on nearby plants. Potential indirect sources of impact included dust, noise, and alteration of runoff, created during geological research, general construction, mining activities. "Treatment" Ecological Study Plots (ESPs) were located adjacent to intensive site characterization activities and compared to "control" ESPs from two control locations at Yucca Mountain or nearby Little Skull Mountain. An unambiguous test of impact was not possible because "before" and "after" periods were not clearly defined and the study lasted only three years. If present, impact should create dissimilarity in the yearly response of vegetation between treatment and controls, which can be tested statistically as the interaction between location and year in an analysis of variance. Because interactions can arise from other causes, significant interactions are considered potential impacts. There was no significant difference in the amount of vegetation or the number of species between treatment and control locations. The yearly response of treatment and control ESPs was generally the same from year to year. Therefore, no potential impacts were detected. One factor that may affect the analysis of potential impact is the similarity between control locations. Control locations were similar in species composition and yearly response of plant cover and perennial plant richness, but were not similar in the yearly response of annual plant richness. Control locations also differed in precipitation, cover, and richness, although spatial variation in these factors is common in the Mojave Desert and probably unavoidable. In this study, differences between control locations made it more difficult to detect potential impact, but easier to avoid Type I error (the false conclusion that impact took place). An analysis of statistical power showed that the power to detect interactions, and potential impact, was very low. (Authors) *Keywords:* YMSCO*, perturbations*, vegetation*, ecology/ecosystem*

292 **HESSING, M.B., G.T. SHARP, and S.R. YORK. 1998. Classification and Map of Vegetation at Yucca Mountain and Little Skull Mountains, Nevada. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00083 Rev 00B. Las Vegas, NV, 13 pp.**

This report describes the vegetation associations of Yucca and Little Skull Mountains, Nevada, and explains how vegetation was sampled and classified. The cover of perennial plants was measured on 358 Ecological Landform Units using plotless sampling methods. Cluster analysis was used to group samples into nine vegetation associations. The distribution of vegetation associations is shown on map YMP-98-153.0, which accompanies this report. A GIS coverage was created to facilitate user-friendly, interactive access to floristic and environmental data from user-specified map locations. The map is an improvement over previous Yucca Mountain vegetation maps because it is based on a hierarchical quantitative classification, includes all major vegetation associations, and covers all areas previously used for plant ecology research. (Authors) *Keywords:* YMSCO*, vegetation*, ecology/ecosystem*, methods*

293 **HESSING J.B., G.E. LYON, G.T. SHARP, W.K. OSTLER, and R.A. GREEN. 1999. The Vegetation at Yucca Mountain: Effects of Site Characterization. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00048 Rev 00. Las Vegas, NV, 43 pp.**

The indirect effects of a landscape-level engineering project on plant communities were studied at Yucca Mountain, Nevada. Using a modified BACI (Before-After-Control-Impact) experimental design that compared treatment plots and control plots before and during site characterization, plant canopy cover, production, and species richness were sampled yearly from 1989 to 1994 on 24 treatment (potentially disturbed) plots and 24 control plots in four vegetation associations. A second analysis tested for the presence of a distance effect that would affect cover and production at different distances from potential impact. No large or moderately sized BACI or distance effects were detected. However, a relatively small, positive BACI effect showed vegetation increased on treatment ESPs, relative to control ESPs, as site characterization activities increased. The cover of annual species and introduced (non-native) annual species also increased slightly, although no indication was found that annual species were replacing shrubs damaged or killed by site characterization activities. The pattern of increasing cover, production, and sample richness differs from most environmental impacts. More dust was deposited on treatment ESPs than on control ESPs. Although dust deposition was greatest near roads, no distance effects on vegetation were detected. The findings of a positive BACI effect but no distance effect were consistent with the array of beneficial and detrimental impacts from site characterization activities. The study period unexpectedly coincided with a climatic cycle of increasing precipitation, causing vegetation measurements to become experimentally confounded with precipitation. Therefore, it must be concluded that the BACI effect was influenced by a combination of site characterization activities and increasing precipitation, and that the effect of the two factors cannot be separated. It is possible that the BACI effect may not be significant under different climatic cycles. (Authors) *Keywords:* YMSCO*, climate*, perturbations*, invasive species*, annual plants*, vegetation*, ecology/ecosystem*

294 **HESSING, M.B., G.E. LYON, G.T. SHARP, W.K. OSTLER, R.A. GREEN, and J.P. ANGERER. 1996. The Vegetation of Yucca Mountain: Description and Ecology. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00030 Rev 00. Las Vegas, NV, 69 pp.**

As part of a site characterization to assess the suitability of Yucca Mountain, Nevada, as a high-level waste repository, vegetation was monitored over a six-year period, from 1989 through 1994. Cover, density, production, and species composition of vascular plants were monitored at 48 Ecological Study Plots (ESPs) stratified in four vegetation associations. Precipitation, soil moisture, and maximum and minimum temperatures also were measured at each study plot. The average percent cover (across all 48 ESPs) ranged from 15 to 28 percent during the 6-year study. Cover on individual

ESPs ranged from 7 percent to 45 percent during the same period. Plant density (measured only in 1991 and 1992 on all ESPs) ranged from 62 individuals 100 m^{-2} in the *Larrea-Lycium-Gray*ia vegetation association to 139 individuals 100 m^{-2} in the *Lycium-Grayia* vegetation association. Net annual aboveground primary production, averaged across all ESPs, ranged from 0.72 kg ha^{-1} in 1989 to 479. kg ha^{-1} in 1992. In 1993, when production measurements were made in the *Larrea-Lycium-Grayia* vegetation association only, production rose to 661 kg ha^{-1}. Major trends and patterns in plant abundance were caused by the interactions of three factors: precipitation (which fluctuated between wet and dry years), vegetation association, and plant life form (annual, shrub, or perennial herb). Mortality and juvenile recruitment averaged 2.7 and 3.2 percent, respectively, over a two-year period in the *Larrea-Lycium-Grayia* association. Seedling recruitment in this vegetation association averaged 9.0 percent during the same period. During cover censuses, 64 perennial species were identified; in the Yucca Mountain vicinity a total of 191 plant species were identified, annual and perennial. Richness and diversity, measured using Shannon's diversity index, increased as the size of the area characterized increased; evenness decreased with sample area. No threatened and endangered plant species, or candidate species, were found. Species composition among ESPs within vegetation associations was generally cohesive and verified the initial field identification. Seasonal precipitation patterns explained approximately 58 percent of the variation in cover and approximately 80 percent of the variation in production. Species composition was significantly

influenced by elevation, soil texture, slope, six-year precipitation total, and average (12-month) maximum temperature. (Authors) *Keywords:* YMSCO*, climate*, vegetation*, ecology/ecosystem*, life history*, methods*

295 HILL, H.O. 1980. Breeding Birds in a Desert Scrub Community in Southern Nevada. The Southwestern Naturalist (25)2:173-180.

Breeding bird populations were studied in a creosotebush community of the northern Mojave Desert in Rock Valley, Nevada, between 1971 and 1973. Two species bred in the dry years (1971, 1972) and five species in the exceptionally wet year (1973). Larger clutches were laid in 1973. The paucity of breeding species was associated with a structurally simple desert community of low productivity. Densities of breeding pairs (46-80/100 ha) were intermediate to densities recorded in other desert scrub environments. The regular breeders-LeConte's Thrasher (*Toxostoma lecontei*) and Black-throated Sparrow (*Amphispiza bilineata*) exhibited high breeding densities (3/100 ha and 43-61/100 ha. respectively) compared to other localities within their breeding ranges. *Keywords:* vegetation*, bird*, life history*

296 HODDENBACH, G.A., and F.B. TURNER. 1968. Clutch size of the lizard *Uta stansburiana* in southern Nevada. Amer. Midland Nat. 80:262-265.

Clutch size of *Uta stansburiana* varies from year to year, with observed differences of as much as one egg per clutch. Fertility is correlated with production of winter annuals. The largest clutches were recorded in 1966, following unusually good growth of winter annuals. It is likely that the abundance of insects available to *Uta* is also related to production of annuals. (Authors) *Keywords:* annual plants*, reptile*, life history*, nutrition/diet*

297 HOLMGREN, N.H. 1971. A new species of Penstemon from Nye County, Nevada. A liso 7:351-356.

Penstemon pahutensis, a new species, was described from material collected by Reveal on Pahute Mesa and Rainier Mesa, Nevada Test Site. (TPO) *Keywords:* sensitive plants*, taxonomy*

298 HOLT, E.A., and J.M. MUELLER. 1994. Monitoring Raven Abundance at Yucca Mountain. In: The Desert Tortoise Council Proceedings of 1994 Symposium, pp. 125-126. Desert Tortoise Council, San Bernardino, CA.

We monitored the abundance of ravens (*Corvus coax*) at Yucca and Bare mountains, Nevada, to determine if activities conducted for the Yucca Mountain Site Characterization Project (YMP) caused an increase in raven abundance. Biologists conducted simultaneous road surveys along a treatment (Yucca Mountain) and control (Bare Mountain) route on five randomly selected weekdays every other month. Each survey route was 40 km long and consisted of 50 stops spaced 0.8 km apart. At each stop, one biologist looked for ravens for one minute and recorded information on location and behavior of all ravens sighted. During a 32-month period beginning August 1991, more ($P=0.02$) ravens were observed on the treatment route ($\bar{x}=3.5$) than on the control route ($\bar{x}$-2.5); and more ($P=0.003$) ravens were observed during the post--disturbance period ($\bar{x}=3.6$) than during the pre-disturbance period ($\bar{x}=2.3$). However, because there was no change in the difference between the number of ravens observed on the two routes ($P=0.9$), we concluded that YMP did not cause an increase in raven abundance at Yucca Mountain over this time period. (Authors) *Keywords:* YMSCO*, bird*, ecology/ecosystem*

299 **HOLT, E.A., and K.R. RAUTENSTRAUCH. 1995. Three-Year Movement Patterns of Adult Desert Tortoises at Yucca Mountain. In: The Desert Tortoise Council Proceedings of 1995 Symposium, pp. 89-90. Desert Tortoise Council, San Bernardino, CA.**

We studied the home-range size and site fidelity of adult (>180-mm MCL) desert tortoises (*Gopherus agassizii*) at Yucca Mountain, Nevada, during 1992-1994. Of 67 adult tortoises monitored at Yucca Mountain during this period, we evaluated the movements of 22 female and 16 male radiomarked tortoises that were located >50 times during each of the 1992, 1993, and 1994 activity seasons. By including only tortoises that were located many times in all three years, we may have biased our sample toward the resident tortoises that were easiest to locate. We used two methods to measure annual and three-year home range size: 100% minimum convex polygon (MCP) (Mohr 1947) and 95% cluster (Kenward 1987). Males had larger annual MCP home ranges ($\bar{x}$= 53 ha, SD = 51) than females ($\bar{x}$ = 18 ha, SD = 12). The average three-year MCP home range also differed between males ($\bar{x}$ = 93 ha, SD = 27) and females ($\bar{x}$ = 27 ha, SD = 17). MCP home ranges did not differ among years ($\bar{x}$ = 33 ha, SD = 39). The average overlap in consecutive annual MCP home ranges was 78% (SD = 19, range = 7-100%, n = 76). There was no difference in percent overlap between sexes across the year groups. Tortoises used an average of 65% of their MCP three-year home range annually (SD = 20, range = 17-100%). This measure did not differ between sexes. We conclude that males have larger home ranges than females and that tortoise movements vary annually, possibly in response to differences in rainfall. Adult tortoises at Yucca Mountain moved less during 1994, which was drier than the previous two years. Although average MCP home range size did not differ among years, tortoises had smaller cluster home ranges in 1994, indicating that they spent most of their time in smaller areas. Tortoises also used smaller portions of their three-year home range in 1994 than they did in the previous two years. In addition, tortoise used fewer areas different from the previous year in 1994 than in 1993. We also conclude that most adult tortoises at Yucca Mountain show strong site fidelity. One reason for this conclusion is that shifts in arithmetic-mean center of activity between consecutive years were small compared to home range sizes. In addition, overlap in consecutive annual home ranges and percentage of the three-year home range used annually were relatively large. It should be noted, however, that a few tortoises we monitored at Yucca Mountain, but did not include in this analysis because we were unable to locate them often enough, moved great distances and had little site fidelity. (Authors) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*

300 **HOOTEN, M.M., J.T. MARKWIESE, T.G. MYLES, P. BLACK, and R. RYTI. 2001. A Literature Review of Biotic Components, Processes, and Characteristics Central to Biotic Transport Modeling of Soils at the Nevada Test Site. Neptune and Company, Inc., Los Alamos, NM.**

The potential for biotic mixing of soils has played a central role in recent performance assessments (PAs) for the containment of buried radioactive waste at the Nevada Test Site (NTS). These PAs have included probabilistic analyses that demonstrate compliance of buried waste practices in accordance with DOE Order 435.1. To date, however, uncertainties and large gaps of biotic information have required undue conservatism to be built into probabilistic models of biotic transport processes of wastes in soils. This conservatism overestimates the probable risk of waste containment at the NTS and does not facilitate decision-making for other aspects of the Department of Energy, Nevada Operations (DOE/NV) low-level waste and transuranic (TRU) waste programs, such as closure, monitoring, and disposal operations. Models are designed to estimate the probable risk from low-level and TRU waste at the NTS for 1,000 to 10,000 years in the future. We have conducted a literature search in order to provide information foundational to the biological assumptions of realistic probabilistic biotic transport models. We have identified plants and animals of the NTS capable of accessing and/or mixing waste when buried, or otherwise accessible (e.g., through upward advection of waste from deeper burial systems) under less than 3 to 5 m of fill. Plants and animals include dominant shrub and tree species at the NTS (about 30 species), several grasses, and numerous mammals, ants, and termites. Plants bioaccumulate contaminants in their tissues, thus redistributing constituents with the loss of shed materials or the death of the plant. Animals also bioaccumulate contaminants but primarily mix near-surface soils as a result of nesting, foraging, and burrowing activities. These fundamental ecosystem processes, which are generally beneficial to the environment, enhance soil aeration, water infiltration, and soil development. These processes also complicate the management of mixed and hazardous waste stored on or in soils. From this work, a conceptual model befitting the details of biotic soil transport modeling can be created. A detailed model can also be used as a basis for creating summary statistics of model parameters using the information provided in this paper. We anticipate using the information provided herein to implement statistical procedures and initiate modeling efforts that will be used to identify the sensitivities of a working biotic transport model. These procedures will also elucidate existing data gaps and uncertainties that have, to date, been obscured by a lack of biotic information regarding soil mixing processes. This work serves as a basis for future research (including fieldwork) in the realm of biotic transport modeling at the NTS and in the desert southwestern U.S. at large. The results of this research provide useful information to decision makers and radioactive or hazardous waste managers for estimating waste isolation integrity over time and for identifying optimal waste disposal options in the future. (Authors) *Keywords:* bibliography*, vegetation*, invertebrate*, vertebrate*, radiation*

301 **HORN, J.M., and A. MEIKE. 1995. Microbial Activity at Yucca Mountain. Part I: Microbial Metabolism, Adaptation, and the Repository Environment. UCRL-ID-122256. Lawrence Livermore National Laboratory, Livermore, CA.**

The U.S. Department of Energy is engaged in a suitability study for a potential geological repository at Yucca Mountain, Nevada, for the containment and storage of commercially generated spent fuel and defense high-level nuclear waste. There is growing recognition of the role that biotic factors could play in this repository, either directly through microbially induced corrosion (MIC), or indirectly by altering the chemical environment or contributing to the transport of radionuclides. As a first step toward describing and predicting these processes, a workshop was held on April 10-12, 1995, in Lafayette, California. The immediate aims of the workshop were: (1) to identify microbially related processes relevant to the design of a radioactive waste repository under conditions similar to those at Yucca Mountain, (2) to determine parameters that are critical to the evaluation of a disturbed subterranean environment, and (3), to define the most effective means of investigating the factors thus identified. The workshop was attended by some of the Yucca Mountain principal investigators and recognized microbiologists (attendees are listed in the Appendix). Key concepts that were identified as a result of this workshop will be presented in two parts. Part I reveals a general perspective that provides a foundation for developing the directions described in Part II (published separately). General aspects of microbial activity of significance to the long-term (10,000-year) perspective of microbial activity are outlined in Part I, Section 1. Generalized aspects of microbial activity that relate to repository conditions are examined in Part I, Section 2. Explicit implications of microbially related processes that might be expected for the Yucca Mountain repository are explored in Part I, Section 3. Part II suggests avenues of investigation that can be used to predict microbial affects in the repository environment. (Authors) *Keywords:* YMSCO*, microbiota*, radiation*

302 **HOUGHTON, J.G. 1969. Characteristics of rainfall in the Great Basin. University Nevada, Desert Research Inst., 205 pp.**

The major objectives of this report were to: (1) explain the characteristics of rainfall in the Great Basin in terms of climatic controls; (2) develop statistical methods for estimating the long-term rainfall regime at stations with incomplete records. The solution to the problem involved statistical techniques based on synoptic rainfall-triggering mechanisms. Analyses showed that rainfall components could be defined by standard curves expressing the associated annual march of rainfall. The Pacific component approximated a sine curve with a January peak and a July-August minimum. The Gulf component occurred only in summer with an August maximum. The Continental component, associated with closed lows developing over the Great Basin itself, varied in shape but generally peaked in the spring and fall. Given the standard curve, the estimated long-term annual march of rainfall could be computed for any station by fitting curves to the station data and combining them into a total curve. The parameter, precipitation effectiveness, is defined in terms of the annual mean rainfall and the deficiency index. The latter two terms are classified in terms of vegetation types, including five categories of annual rainfall and seven categories of deficiency. Finally, the precipitation effectiveness is expressed in terms of climatic types representing the two factors combined. (TPO) *Keywords:* climate*, ecology/ecosystem*

303 **HOUSMAN, D., S.F. ZITZER, J. COLEMAN, R.S. NOWAK, and J. SEEMANN. 1999. Survival and growth characteristics of naturally recruited seedlings of Mojave Desert shrubs *Larrea tridentata* and *Ambrosia dumosa* exposed to elevated atmospheric CO_2 (FACE) during a wet year. In: Symposium Abstracts, The Ecological Society of America 84th Annual Meeting, August 8-12, 1999, Spokane, WA.**

Positive growth responses to elevated CO_2 have been documented for annual and perennial plants from diverse ecosystems. However, responses to elevated CO_2 by natural populations of desert shrubs recruited in undisturbed sites have not been documented. We employed FACE (Free Air Carbon Dioxide Enrichment) technology to begin continuous atmospheric CO_2 enrichment to 550 ppm in an undisturbed Mojave Desert plant community in April 1997. We then began quantifying survival and growth responses in September 1997 by naturally recruited seedlings of *Larrea tridentata*, a dominant evergreen shrub, and *Ambrosia dumosa*, a dominant deciduous shrub. Seedling density of 0.50 ml for *Ambrosia* was greater than the 0.056 m^{-2} for *Larrea* and seedling densities were not effected by elevated CO_2 for both species. Overall seedling survival after 12 mo for *Ambrosia* (67%) was greater than *Larrea* (42%). Survival of all seedlings under elevated CO_2 (69%) was greater than under ambient CO_2 (40%). Seedling survival rates for both species was greater in an open location than in a shrub understory. Only height growth for *Larrea* was greater under elevated CO_2 These results suggest population densities of desert shrubs may significantly increase under predicted levels of increasing atmospheric CO_2, especially during wet years. (Authors) *Keywords:* FACE*, perturbations*, perennial plants*, ecology/ecosystem*

304 **HOWARD, W.A. 1984. Summarizing History of the Nevada Applied Ecology Group's Environmental Studies of Transuranics & Other Radionuclides. NVO-274. Nevada Applied Ecology Group, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV.**

This historical summarization of the Nevada Applied Ecology Group's (NAEG) integrated applied research program is based on published proceedings of the Information Conferences, Symposia, and Workshops held since the inception of the program in 1970. The NAEG was formed in 1970 as an outgrowth of the formation of the Office of Effects Evaluation in 1969 and an anticipation by DOE/NV management of what was to become the National Environmental Policy Act of 1969. It was formed to study all ecological problems, however plutonium in the environment became the first matter of concern. The scope of the program was later expanded to include other transuranics and other radionuclides as well. The information gained from these studies would enable the nuclear testing program to better fulfill its responsibilities to environmental problems and the interests of the public at large concerning environmental quality. The tasks assigned or proposed for each field of study by year are briefly described. They include tasks for studies related to soils, soil surveys and profile descriptions, vegetation, large vertebrate, small vertebrates, chickens, microorganisms, resuspension of plutonium, and the distribution and inventory of radionuclides in NTS surface soil. (Author) *Keywords:* NAEG*, radionuclide inventory*, microbiota*, vegetation*, vertebrate*, radiation*

305 **HOWARD, W.A., and R.G. FULLER, Eds. 1987. The Dynamics of Transuranics and Other Radionuclides in Natural Environments (Howard, W.A., and R.G. Fuller, Eds.). U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV. NVO-272, pp. 565**

The Plutonium Information Conference of the NAEG was held June 28-30, 1983 in Las Vegas, Nevada. This document contains the research reports presented at the conference. The NAEG investigators have provided an update of the various environmental transuranics (and other radionuclides) studies currently in progress at the Nevada Test Site. This work is the continuation of ongoing research programs. Reports focus in the areas of distribution and inventory, vegetation, soils, resuspension, small animals, large animals, statistics, modeling, and hydrology. (Authors/WKO) *Keywords:* NAEG*, hydrology*, soil property*, radionuclide inventory*, vegetation*, mammal*, ecology/ecosystem*, radiation*, methods*

306 **HOWARD, W.A., P.B. DUNAWAY, and R.G. FULLER (Eds.). 1985. The Radioecology of Transuranics and Other Radionuclides in Desert Ecosystems. NVO-224. U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV.**

This Nevada Applied Ecology Group (NAEG) publication is the result of a workshop held at the Department of Energy's Nevada Operations Office, Las Vegas, Nevada, on January 29-30, 1980. The NAEG investigators have provided not only an update of the various environmental transuranic (and other radionuclides) studies currently in progress at the Nevada Test Site (NTS), but also plans for future activities necessary to logically complete the delineated goals of the NAEG. These investigations are part of an integrated applied research program designed to provide information on the radioecology of transuranics (and other radionuclides) movement in the environs of the NTS; to predict any possible associated dose to man; and to recommend related cleanup and treatment, if required, for radioactively contaminated areas. This work is the continuation of research programs which are reported in previous NAEG publications. The previous NAEG publications are listed on page 362, and those of the Nevada Applied Ecology Information Center (NAEIC) are listed on page 363 of this publication. Studies in the safety-shot areas were not completed according to the anticipated schedule due to a diminution of funding levels. However, increased emphasis will be focused on studies in the nuclear-event sites in the future. (Authors) (CAW) *Keywords*: NAEG*, radionuclide inventory*, microbiota*, vegetation*, mammal*, nutrition/diet*, ecology/ecosystem*, radiation*

307 **HUGHES, A.L., K.R. RAUTENSTRAUCH, and D.L. RAKESTRAW. 1994. Hibernation Behavior of Desert Tortoises at Yucca Mountain, Nevada. In: The Desert Tortoise Council Proceedings of 1994 Symposium, p. 158. Desert Tortoise Council, Inc., San Bernadino, CA.**

We determined when radiomarked desert tortoises (*Gopherus agassizn*) hibernated at Yucca Mountain, Nevada, during 1991-1993. The mean dates tortoises entered hibernacula were 25 October 1991 (n = 76, SD = 12.3, range = 28 Sep - 7 Dec), 22

October 1992 (n = 83, SD = 13.7, range = 12 August - 21 Nov), and 16 October 1993 (n = 95, SD=13.4, range = 18 August - 19 November). By 15 November, 97% of all tortoises had entered hibernacula. The mean dates tortoises exited hibernacula were 27 March 1992 (n = 79, SD = 13.7 days, range = 27 Feb - 2 May) and 24 March 1993 (n = 78, SD = 12.3 days, range = 5 March - 25 April). Only one tortoise exited its hibernaculum prior to 1 March. Radiomarked tortoises were checked 2,198 times between December and February, and undisturbed tortoises were seen out of hibernacula only once. Tortoises handled during the hibernation period exited hibernacula earlier than tortoises that were not handled. We conclude that tortoises in this region do not need to be monitored during construction activities from November 15 through March 1. (Author) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*

308 **HUNTER, R.B. 1984. Seedling Establishment and Growth on a Mojave Desert Disturbed Site. CIC 0083202. University of California, Los Angeles, 21 pp.**

Survival and growth of natural shrub seedlings was followed from 1978 to 1981 on a borrow pit in the Mojave Desert, U.S.A. The primary cause of death (>75%) was browsing by small mammals - mostly jackrabbits and gophers. Browsing damage was quite severe until plants approached a canopy volume of 10%. Fencing of new seedlings reduced mortality significantly, but fencing of year-old plants did not. Intensity of browsing, tissues eaten, and plant response to browsing varied among plant species. Species composition of the seedling community differed from that of the adjacent mature community, and seedlings on the disturbed site were more frequently browsed than were those in the mature vegetation. (Author) *Keywords:* perennial plants*, mammal*, ecology/ecosystem*, life history*

309 **HUNTER, R.B. 1987. Jackrabbit-Shrub Interactions in the Mojave Desert. In: Proceedings of the Symposium on Plant Herbivore Interactions. USDA Forest Service, Intermountain Research Station Report, INT-222. Ogden, UT, pp. 88-92.**

Jackrabbits in the Mojave Desert have been shown to be severely water stressed during dry weather. I postulate that, rather than being absolutely dependent on drinking water, they utilize vegetation growing on the more mesophytic microhabitats. Season, local soil moisture reserves, and local soil fertility were significant variables determining jackrabbit utilization of desert shrubs. With few exceptions, plant species appeared to be of less significance to browsing preference than moisture and nutrient levels. (Author) *Keywords:* perennial plants*, mammal*, nutrition/diet*, ecology/ecosystem*

310 **HUNTER, R.B. 1988. Contribution of Groundwater to Mojave Desert Shrub Transpiration. DOE/NV/10327-T3, Laboratory of Biomedical and Environmental Sciences, University of California, Los Angeles, CA.**

Soil moisture was measured to 112-m depths in the northern Mojave Desert on two plots, one of which was denuded of shrubs. The pattern of wetting-drying near the surface and below the depth wet by rainfall suggested roughly 2 mm per month of transpired water was supplied by percolation upward from below the root zone. This deep moisture built up during fall and winter and depleted in spring and summer, which correlates well with local shrub phenology. (Author) *Keywords:* climate*, soil property*, perennial plants*, physiology*

311 **HUNTER, R.B. 1989. Competition Between Adult and Seedling Shrubs of *Ambrosia dumosa* in the Mojave Desert, Nevada. Great Basin Naturalist 49(1):79-84.**

Seeds of the perennial shrub *Ambrosia dumosa* germinated in abundance following 11 days of rain during August 1983 at a study site in the northern Mojave Desert. Seedling establishment, growth, and reproduction were observed in natural vegetation and in an area that had been previously cleared of vegetation. For 5,527 *A. dumosa* seedlings, percent survival in April 1986 averaged 3% in the undisturbed vegetation and 58% in the denuded area. Seedlings occupying the cleared area had grown to sizes up to 0.1 m^3 by October 1984; some produced flowers and fruit in the spring of 1985. Surviving seedlings in the undisturbed vegetation were all smaller than 0.001 m^3 and did not reproduce. These pronounced differences in growth, survival, and reproduction associated with the presence or absence of adult shrubs demonstrated an intense competition that is incompatible with indications of mild competition from nearest-neighbor analyses. I therefore hypothesize that competition for water occurred, not by competition for water in two dimensions but by rapid use of a common resource, as if several people were drinking with straws from a common cup. This temporal mechanism would strongly favor adults over seedlings. (Author) *Keywords*: perturbations*, perennial plants*, ecology/ecosystem*

312 **HUNTER, R.B. 1989. Recent Increases in *Bromus* Populations on the Nevada Test Site, pp. 22-25. In: Proceedings of the Symposium on Cheatgrass Invasion, Shrub Die-off, and Other Aspects of Shrub Biology and Management. McArthur, E.D., E.M. Romney, S.D. Smith, and P.T Tueller (Eds.), Las Vegas, NV, April 5-7, 1989. Gen Tech. Rep. INT-276. USDA Forest Service, Ogden, UT.**

Two introduced grass species, red brome *(Bromus rubens* L.) and cheatgrass (*Bromus tectorum* L.), have invaded the Mojave and Great Basin Desert vegetation of the Nevada Test Site. One or the other dominates most ephemeral populations. They occur in densities up to thousands per square meter. The ecosystem changes resulting from the grasses include an increased tendency for propagation of fire and a possible decrease in diversity of the native ephemeral flora. (Author) *Keywords:* invasive species*, annual plants*, ecology/ecosystem*

313 **HUNTER, R.B. 1991. *Bromus* Invasions on the Nevada Test Site: Present Status of *B. rubens* and *B. tectorum* with Notes on Their Relationship to Distribution and Altitude. Great Basin Naturalist 51(2):176-182.**

Bromus rubens and *Bromus tectorum* are now nearly ubiquitous components of the Nevada Test Site (NTS) flora. Introduced to the western United States in the late 1800s, they spread through the Mojave and Great Basin deserts in the early twentieth century. Since quantitative studies began on the NTS in 1957, *Bromus* spp. have greatly increased in frequency and density. By 1988 both species occurred in many places at densities exceeding 1,000 individuals per square meter. They may significantly increase flammability of the vegetation and reduce success of native ephemeral species. (Author) *Keywords:* invasive species*, annual plants*, ecology/ecosystem*

314 **HUNTER, R.B. 1992. Lessons from five years of vegetation monitoring on the Nevada Test Site. Prepared for Ecology, Management and Restoration of Intermountain Annual Rangelands Symposium, Boise, ID, 18-21 May 1992. DE92040577, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, 25 pp.**

In 1987 the U.S. Department of Energy funded a formal, extensive monitoring program for the flora and fauna on the Nevada Test Site. The goal was to understand and record changes with time in the distribution and abundance of the plants and animals. The need to detect changes, rather than do a one-time characterization, required careful selection of parameters and the use of permanent plots to distinguish spatial from temporal variability. Repeated measurements of the same plots revealed errors and imprecision which required changes in training and data collection techniques. Interpretation of trends after several years suggested it will be important to monitor not only changes, but causes of change, such as soil moisture and herbivory. Finally, the requirement for records to be available over long periods of time poses problems of archiving and publication. This report consists of viewgraphs presenting the findings of the study. (Author) *Keywords:* vegetation*, ecology/ecosystem*

315 **HUNTER, R.B. 1992. Status of Desert Ephemerals on the Nevada Test Site in 1988. In: Status of the Flora and Fauna on the Nevada Test Site, 1988. Hunter, R.B. (Compiler), DOE/NV/10630-29, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 9-58.**

The desert areas of the Nevada Test Site (NTS) produce massive and beautiful displays of winter ephemerals every five to ten years (Went and Westergaard 1949). These floral displays result from germinating rainfall in late September through early November, followed by sufficient spring rainfall for good growth (Beatley 1974). In addition, each year there is a significant population of introduced grasses mixed with small numbers of native ephemerals, which germinate from fall through early spring, and grow a variable amount, depending upon weather conditions. Winter ephemeral plants start as germinating seeds and produce virtually their entire substance using the resources available during growth. The densities are largely a function of seed reserves and rainfall/ temperature conditions. Over the short term, densities are affected by human disturbances such as scraping and fires, which reduce seed reserves; salt, shading, and chemical pollutants, which reduce or enhance germination; and compaction and toxins, which reduce establishment. Following germination and establishment, final individual plant sizes and reproduction are affected by soil moisture; fertility and toxicity; shading; temperature fluctuations; and crowding. Over a longer time span ephemeral populations are subject to competitive interactions with other species, including differential responses to grazing; disturbance; soil weathering; and minute additions of nutrients through rainfall, nitrogen fixation, and similar natural processes. The greatest in magnitude of these interactions are probably biological ones (Janzen 1986). Ephemeral populations are, therefore, sensitive to many types of disturbance. One objective of the NTS Basic Environmental Compliance and Monitoring Program (BECAMP) is to determine and understand the changes in the fauna and flora with time. To accomplish this task BECAMP measures ephemeral population characteristics (species composition, densities, and sizes) at sites scattered around the NTS. Some are baseline sites with human disturbances limited as much as possible to widespread airborne pollutants. BECAMP purposely selected a greater number of sample sites that are representative of human (Department of Energy related) disturbances on the NTS. Examples are aboveground blast areas from 1950s tests, subsidence craters, roadsides, construction areas, and areas contaminated by radionuclides. A few are disturbed by natural forces such as lightning-initiated fires and gophers. The winter of 1987 and spring of 1988 were relatively normal, in that rainfall was limited and sporadic, and temperatures were low. (See Turner and Randall [1989] on correlations of rainfall with ephemeral production.) Some germination of annuals occurred in the warmer areas in early to mid-November 1987, following rainfall in late October varying from 17 to 38 mm. Only sparse rain fell in the best growing season, March-April 1988, however, so plants were small and fruited poorly, if at all. Variations within that generalization occurred in a normal manner, such that more fertile sites and those with reduced evaporation and transpiration produced larger or more numerous plants. BECAMP ecology efforts in 1988 were directed toward monitoring the status of ephemerals on five baseline sites, two burned areas, three blast zones of 1950s atmospheric nuclear bomb tests, a roadside, and a site scraped in 1987 during clean-up operations on a 1950s era radioactive waste dump. (Author) *Keywords:* climate*, perturbations*, invasive species*, annual plants*, ecology/ecosystem*, life history*

316 HUNTER, R.B. 1992. Status of Perennial Plants on the Nevada Test site in 1988. In: Status of the Flora and Fauna on the Nevada Test Site, 1988. Hunter, R.B. (Compiler), DOE/NV/10630-29, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 183-229.

Perennial plants are the major producers of biomass on the Nevada Test Site (NTS). They normally cover 20 to 30% of the surface at lower elevations, and 40 to 50% on the mesas (Beatley 1979), providing food and cover to the desert animals. They are ubiquitous except on the dry lake beds (playas) and newly disturbed areas. Most habitats support long-lived desert shrubs, mixed with sparse short-lived herbaceous perennials and winter ephemerals. The higher altitudes also support juniper trees (*Juniperus osteosperma*) and/or juniper mixed with pinyon pines (*Pinus monophylla*). The shrub vegetation on the NTS has been studied since 1958 (reviewed in Hunter and Medica 1989). Changes in the populations are relatively slow (Beatley 1976), on the scale of human life spans. Recovery of the vegetation following disturbance is also slow (Webb and Wilshire 1980; Lathrop and Archbold 1980), and recovery to an equilibrium status may never occur, given the documented long-term fluctuations in the world's climate since the last ice age (see for example Van Devender and Spaulding 1979). As such, the plant community is "fragile", though the individuals comprising it are adept at survival in a very harsh environment. There are about 436 perennial plant species and subspecies inhabiting the NTS. By far the majority are uncommon, leaving a few species to dominate the vegetation in most areas. The dominant species (Table 6.1) are uniformly long-lived (decades to centuries) and very drought-tolerant. They do not invade disturbed areas rapidly, and those species which do are often absent or poorly represented in undisturbed habitats. Natural causes of mortality in mature plants are gophers, windfall, self-shading problems associated with old age or large size, fires and floods, drought, and insects. The Basic Environmental Compliance and Monitoring Program (BECAMP) was established in 1986 by the Department of Energy Nevada Field Office (DOE/NV) to assess changes over time in the radiological and ecological condition of the NTS and to provide information needed for NTS compliance with environmental laws. The ecological studies are intended to record the spatial distributions of the flora and fauna and their changes with time on the NTS. The purpose of the perennial plant measurements is to determine population densities and plant sizes at particular locations, and to monitor changes in those variables by repeated measurements at intervals of one to five years. Because the perennial populations change slowly, monitoring changes is considered a long-term undertaking, requiring the maintenance of permanently marked sample populations and extended maintenance of records on individual plants for long periods. Nineteen-eighty-eight was the second year of sampling of perennial plants for the BECAMP program, and thus the first year for comparison of data between years. The resulting change in analytical procedures was still in experimental stages, but allowed an enhanced assessment of the changes occurring in the desert shrub communities sampled. Areas sampled in 1988 included five baseline sites, three ground zeros from 1950s bomb tests, the scraped edge (verge) of an abandoned road, and a newly scraped site. (Author) *Keywords:* climate*, perturbations*, perennial plants*, ecology/ecosystem*, life history*

317 HUNTER, R.B. (Compiler). 1992. Status of the Flora and Fauna on the Nevada Test Site, 1988. DOE/NV/10630-29, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, 229 pp.

This report describes continuing efforts to monitor the flora and fauna of the Nevada Test Site. In addition to studying ephemeral and perennial plants, small mammals, and reptiles, wildlife usage was monitored at springs and other water sources on the NTS. Five baseline sites, two areas with vegetation removed by 1950s atmospheric nuclear weapons tests and three other sites that had been disturbed by DOE activities were sampled in 1988. Study sites were sampled for total perennial species as measured on belt transects, cover, plant density and plant biomass. Perennial plants on the NTS were generally static from 1987 to 1988. Density of herbaceous forbs declined from 1987. The most common species found on the undisturbed plots in 1988 was *Uta stansburiana* which ranged from 33 to 122 per hectare while on disturbed plots densities were from 0 to 54 per hectare. A total of 14 species of lizards with observed. Small mammal populations on disturbed sites showed reduced numbers on two common species, *Dipodomys microps* and *Perognathus longimembris*. *Dipodomys merriami* showed no reduction in population numbers in disturbed sites. Common species seen at the springs and water sources were horses, chukar, Gambel's quail, mourning doves, mule deer and migratory waterfowl. (Author) *Keywords:* climate*, perturbations*, wetlands*, annual plants*, perennial plants*, reptile*, bird*, mammal*, ecology/ecosystem*, life history*

318 **HUNTER, R.B. 1994. Status of Ephemeral Plants on the Nevada Test Site, 1992. In: Status of the Flora and Fauna on the Nevada Test Site, 1992. Hunter, R.B. (Compiler), DOE/NV/11432-58, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 1-30.**

Ephemeral populations on the Nevada Test Site in 1992 were favored by a relatively wet winter. Densities increased moderately over 1991, and biomass produced was considerably greater. The populations in subsidence craters were largely the same as on control plots, though growth on the south-facing crater slopes was increased late in the season. The dominance of the ephemeral flora by introduced species continued, though *Bromus rubens* populations were greatly decreased by drought from 1989 - 1990. *Salsola australis* grew well in several areas during summer. Monitoring results are beginning to show significant competition for resources between ephemeral and perennial plants. (Author) *Keywords:* perturbations*, invasive species*, annual plants*, ecology/ecosystem*

319 **HUNTER, R.B. 1994. Status of Ephemeral Plants on the Nevada Test Site in 1993. In: Status of the Flora and Fauna on the Nevada Test Site, 1993. Hunter, R.B. (Compiler), DOE/NV/11432-162, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 150-215.**

Ephemeral populations on the Nevada Test Site in 1993 increased in most places to thousands per square meter, a result of heavy rains in December 1992 and January - February 1993. Biomass did not generally increase proportionately, and in some locations density was constant from 1992 to 1993. Three burned areas were censussed. There were few differences between the burned and control plots. Ephemerals continued to increase-on a shrub-removal plot in Mercury, indicating shrubs inhibit ephemeral population growth. Plots sprayed with a grass-specific herbicide for a second year provided only weak evidence of competition between native species and the dominant introduced grasses. Roadside weeds were examined along Mercury Highway to find evidence for change in ephemeral populations near roads. Most of the weed species examined did not appear to be associated with roadside disturbance, and were as common 35 to 70 m from the road as at 5 and 15 m. (Author) *Keywords:* perturbations*, invasive species*, annual plants*, ecology/ecosystem*

320 **HUNTER, R.B. 1994. Status of Perennial Plants on the Nevada Test Site, 1992. In: Status of the Flora and Fauna on the Nevada Test Site, 1992. Hunter, R.B. (Compiler), DOE/NV/11432-58, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 176-207.**

Measurement of perennial plants on the Nevada Test Site in 1992 revealed some recovery from drought damage incurred from 1988 through 1991. Rainfall was better than any year since 1984, but growth was limited by seasonality of the precipitation and the severely reduced sizes of most shrubs. Germination of new perennial plants was sparse, but the bunchgrass *Oryzopsis hymenoides* and the shrub *Atriplex canescens* had widespread but scattered germination, and herbaceous sub-shrubs like *Sphaeralcea ambigua* and *Mirabilis pudica* increased in size and numbers. On Pahute Mesa sagebrush species (*Artemisia nova* and *A. tridentata*) germinated in large numbers. Pinyon pine (*Pinus monophylla*) trees near 17 Camp were damaged by scale insects (*Matsucoccus acalyptus*), but the infestation ended in 1992. Vegetation was monitored in three subsidence craters. Changes in the craters were complex, mediated by drought, disturbance, and the aspects of the different slopes. At middle elevations (1,400 to 1,600 m) there was little change over three years in the shrub populations of a scraped area in Mid Valley or a burned site in Red Rock Valley. *Oryzopsis hymenoides* increased in density on the burned site, which was moderately grazed by feral horses. (Author) *Keywords:* climate*, perturbations*, perennial plants*, ecology/ecosystem*, life history*

321 **HUNTER, R.B. 1994. Status of Perennial Plants on the Nevada Test Site in 1993. In: Status of the Flora and Fauna on the Nevada Test Site, 1993. Hunter, R.B. (Compiler), DOE/NV/11432-162, Reynolds Electrical & Engineering Co., Inc.,**

Las Vegas, NV, pp. 216-296.

Perennial plants were measured in 1993 on pristine areas, two burned sites, and two roadsides. Shrubs grew in most areas as a result of heavy winter rainfall. There was almost no germination of new plants, however. Growth was more rapid on burned areas and roadsides than on undisturbed areas. Total live volumes of perennial plants were at or above equilibrium values suggested by rainfall patterns at undisturbed sites. (Author) *Keywords:* climate*, perturbations*, perennial plants*, ecology/ecosystem*, life history*

322 HUNTER, R.B. 1994. Trends in Ephemeral Plant Populations on the Nevada Test Site, 1989-1991. In: Status of the Flora and Fauna on the Nevada Test Site, 1989-91. Hunter, R.B. (Compiler), DOE/NV/11432-57, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 334-377.

Ephemeral plant populations (winter annuals and some below-ground perennials) are being monitored on the Nevada Test Site in order to determine the effects of natural forces and Department of Energy activities. This report gives results from the years 1989, 1990, and 1991, and compares them to data collected from 1957 to the present. A major change is a widespread and continuing increase in populations of several introduced weedy species, the most significant being *Bromus rubens*, a weedy annual grass. Some evidence is presented that the introduced species are having deleterious effects on populations of native species. Areas of past and recent disturbance (mostly ground zeroes, subsidence craters, burned areas, and roadsides) have local effects that favor some of the introduced species, as well as ephemeral species in general. Miscellaneous interactions with shrub, mammal, bird, and reptile populations are discussed. (Author) *Keywords:* perturbations*, invasive species*, annual plants*, ecology/ecosystem*

323 HUNTER, R.B. 1994. Trends in Perennial Plant Populations on the Nevada Test Site - 1989-1991. In: Status of the Flora and Fauna on the Nevada Test Site, 1989-91. Hunter, R.B. (Compiler), DOE/NV/11432-57, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 236-333.

Perennial plant populations have been measured annually on the Nevada Test Site at numerous locations since 1987. This report covers the calendar years 1989 through 1991, a period dominated by severe drought. Studies were performed to document vegetation changes associated with natural climate "fluctuations, natural and man-caused fires, animal disturbances, and the activities of the Department of Energy. The studies of DOE effects included progress of recovery from above ground nuclear weapons tests conducted in the 1950s, the changing patterns of vegetation on the slopes of subsidence craters generated by underground weapons tests, recovery of vegetation on scraped areas, the changes in perennial vegetation associated with active and abandoned roads, and changes downwind of a facility testing spills of toxic and hazardous gases. By far the major influence on vegetation during the study period was drought, which selectively killed most perennial bunchgrasses and many shrubs below 1,500 meters. In some locations virtually the whole perennial plant population was killed. In most areas, however, the drought-hardy dominant species survived with moderate to severe dieback, and the more sensitive species died. Recovery of vegetation, which may be considered "succession", was delayed or set back significantly. Survival of bunchgrasses was greatest on disturbed areas, and some recovery on burned areas proceeded. There was evidence for better bunchgrass survival and recruitment on the north-facing slopes of subsidence craters, and shrub survival was enhanced within 15 meters of an active paved road. Recensusing of plots sampled in historical studies suggests there has been little change in the undisturbed NTS vegetation since the early 1960s. However, there are suggestive data showing a significant growth in size of shrubs near Frenchman Lake from 1981 through 1988, followed by severe die-back during the drought. Significant recovery of native shrub communities since 1962 is evident on the Sedan cratering experiment ground zero, with invasion of grasses on the area of throw out deposits occurring between 1975 and 1988, and shrub invasion up to the margin of throw out deposits. Only sparse recruitment of new shrubs occurred in Mid Valley since a fire in 1959. In general, historical data were not adequate to measure subtle changes in vegetation, and too scarce to compare plant species distributions over long time periods. The 1989 through 1991 efforts included significant efforts to improve the quality of data collection and analysis procedures. Comparing data from a single site from 1987 through 1989 showed significant numbers of plants are not obvious to inexperienced observers, and much of the population turnover and new recruitment was not possible to distinguish from measurement errors without improved search and measurement techniques. By 1991, techniques were implemented which resulted in accurate recognition and recensusing of 91% of individuals censussed the previous year, compared to only 41% in 1989-1990. The improved techniques allowed recognition of the establishment of new seedlings and the disappearance of small and dead plants. The techniques established during this period should allow effective monitoring of temporal vegetation changes on the NTS in the future. (Author) *Keywords:* climate*, perturbations*, perennial plants*, ecology/ecosystem*, life history*

324 **HUNTER, R.B. (Compiler). 1994. Status of the Flora and Fauna on the Nevada Test Site, 1989-91. DOE/NV/11432-57, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, 333 pp.**

This report describes continuing efforts to monitor the flora and fauna of the Nevada Test Site. In addition to studying ephemeral and perennial plants, small mammals, reptiles, and wildlife usage at springs and other water sources on the NTS, feral horses were included in the monitoring plan. Perennials were monitored at the five baseline sites and the disturbed areas. Perennial vegetation was severely impacted by the drought from 1989 through 1991. In several areas the perennials were dormant, died back or died altogether. Ephemeral plants were also affected by the drought and showed very low densities during this period. Lizard populations were also affected by the drought. The most common species, *Uta stansburiana,* had populations levels decline by 50%. Small mammal populations on the NTS showed similar declines. Bird monitoring began in 1988 with the number of quail and doves sighted at water sources declining until 1990 and then recovering in 1991. Horses were also monitored and population size estimated. The number of horses range from 57 - 59 adults with variable numbers of foals and yearlings. Adult survival is good but foaling rates were low and foal survival was low. (WKO) *Keywords:* climate*, perturbations*, wetlands*, annual plants*, perennial plants*, reptile*, bird*, mammal*, ecology/ecosystem, life history*

325 **HUNTER, R.B. (Compiler). 1994. Status of the Flora and Fauna on the Nevada Test Site, 1993. DOE/NV/11432-162. Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, 296 pp.**

This report describes continuing efforts to monitor the flora and fauna of the Nevada Test Site. Parameters monitored in 1993 included ephemeral and perennial plants, small mammals, reptiles, wildlife usage at springs and other water sources, and feral horses. Rainfall in 1993 was very high with more than 200 mm falling between December 1992 and March 1993. Ephemeral density increased compared to 1992 levels but biomass remained about equal to 1992 levels. Perennials generally increased moderately in biomass, as shrubs continued to recover from effects of drought. Live volumes increased to exceed pre-drought values. Lizard populations were high in 1993. Small mammal populations continued to recover. Diversity was good although *Perognathus longimembris* numbers continued a decline begun after the 1989-1990 drought. *Dipodomys microps* numbers increased to make it the most abundant rodent in 1993. The number of birds and deer appeared stable in 1993. Horse numbers declined slightly from 65 to 62 adults and foal mortality continued at a high rate. (WKO) *Keywords:* climate*, perturbations*, wetlands*, annual plants*, perennial plants*, reptile*, bird*, mammal*, ecology/ecosystem*, life history*

326 **HUNTER, R.B. 1995. Status of Ephemeral Plants on the Nevada Test Site, 1994. In: Status of the Flora and Fauna on the Nevada Test Site, 1994. Hunter, R.B. (Compiler), DOE/NV/11432-195, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 183-244.**

Ephemeral plants have been monitored on the NTS in order to determine trends in undisturbed populations and to monitor effects of DOE operations on those populations. In 1994 six undisturbed populations scattered over the NTS were sparse, producing 0 to 1.6 ± 1.5 g/m^2 by May, consistent with low winter rainfall. Regression equations, which crudely predict ephemeral biomass from rainfall data, were derived for Yucca Flat ($r^2 = 0.81$) and Rock Valley ($r^2 = 0.90$) baseline plots. Effects of DOE operations were examined at five sites of above-ground nuclear explosions, one scraped and leveled drill pad, and a revegetated waste-cleanup site. For comparison, a rodent denuded area and an area of hand removed shrubs were examined. Wherever shrubs and other perennial plant live volume was reduced, ephemeral population densities were greater than controls, regardless of cause of removal. On disturbed areas, when shrubs had recovered to near-control live-volumes, ephemeral numbers and biomass were not different from undisturbed areas. Effects of introduced brome-grasses on native populations in the lower altitudes were examined on four plots where the *Bromus* species were partially removed. Only one plot showed significant increases in native species. In Mercury Valley, the small native grass *Vulpia octoflora* was approximately 20 times as dense on the removal plot as on the control. In addition, in Rock Valley, the short-lived herbaceous perennial *Eriogonum inflatum* survived better from previous years on the *Bromus* removal plot. Other species germinated in 1994 in densities too low to test for significant effects. (Author) *Keywords:* perturbations*, invasive species*, annual plants*, ecology/ecosystem*, revegetation*

327 **HUNTER, R.B. 1995. Status of Perennial Plants on the Nevada Test Site, 1994. In: Status of the Flora and Fauna on the Nevada Test Site, 1994. Hunter, R.B. (Compiler), DOE/NV/11432-195, Reynolds Electrical & Engineering Co., Inc., Las**

Vegas, NV, pp. 245-349.

This is a progress report of studies monitoring the effects of DOE activities and natural forces on flora and fauna of the NTS in both time and spatial distribution. In 1994, perennial plant populations were monitored on five sites of above-ground nuclear weapons tests, one scraped and leveled drill pad, a revegetated plot, and one rodent-denuded site. In addition, general trends in perennial populations were monitored at baseline sites in each of the NTS' three major valleys and two mesas. The primary technique was censusing of perennials on permanent 100-m^2 belt transects established between 1976 and 1990. Those data were supplemented by censusing individually marked plants of certain low-density species on several baseline sites. Disturbed sites were recensused after a 3-4 year hiatus, while baseline sites were sampled annually for the third or fourth year. Germination and establishment of perennial grasses and/or the shrub *Chrysothamnus nauseosus* was evident 1,000 feet north of Sedan Crater and the T2 blast area in northern Yucca Flat, and on U19ac drill pad on Pahute Mesa. Growth of previously established populations of the shrub *Hymenoclea salsola* and the subshrub *Sphaeralcea ambigua* increased live perennial volume to near control values on the T4 blast area and within 3,000 feet from Sedan Crater. Small perennial populations on two blast areas; T1 and T3, in central Yucca Flat, declined in total live volume between 1991 and 1994, despite favorable growing conditions in 1992 and 1993. Growth of transplanted *Atriplex canescens* on the revegetated area increased total live volume above the adjacent control area. Perennial live volume on the rodent-denuded area remained at < 10% of the control, as it has been since 1988. Live volume on baseline plots generally declined slightly from 1993, as expected from low rainfall in 1994. A separate study was performed to determine the generality of species composition differences associated with a roadside in Frenchman Flat. Species composition was assessed along 50-m lines adjacent to paved roads and in nearby undisturbed vegetation at 95 random points. Similarity of species composition between the two areas was less than expected from removal of species along the roadside, indicating some species are significantly associated with the new roadside habitat, others with the controls. (Author) *Keywords:* perturbations*, perennial plants*, ecology/ecosystem*, life history*, revegetation*

328 HUNTER, R.B. (Compiler). 1995. Status of the Flora and Fauna of the Nevada Test Site, 1994. DOE/NV/11432-195. Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, 363 pp.

This is the final progress report of a Department of Energy (DOE), Nevada Operations Office (NV), program to monitor the ecology of the Nevada Test Site (NTS). The eight-year Basic Environmental Compliance and Monitoring Program (BECAMP) monitored spatial and temporal changes of plants and animals on the NTS to determine the effects of DOE operations on those plants and animals. Determination of the changes was addressed through monitoring the most common plant and animal species at undisturbed (baseline) plots located in the major NTS valleys and mesas. One plot in Yucca Flat, the site of most nuclear weapons tests, was monitored annually, while other baseline plots were censused on a three- or four-year cycle. Effects of DOE operations were examined at sites of major disturbances, related to both DOE operations and natural disturbance mechanisms, censused on a three-year cycle. This report concentrates on work completed in 1994. Populations of winter annual plants, small mammals, and lizards are correlated with winter rainfall, and those populations declined significantly during 1994. Winter annuals germinated only sparsely, as density in Yucca Flat fell from 1762/m' in 1993 to 112/m2 in 1994. Biomass declined from 18.1 to 1.6 g/m2. Shrubs shrank slightly as total live volume declined from 192 to 183 liters/m2. Density of perennial plants declined more than volume, as seedlings which germinated in 1992 and 1993 died. Density of small mammals increased slightly (50 to 53/ha) as a result of excellent reproduction in 1993. However, mean weight of small mammals declined, especially in adult females, indicating reproduction was poorer in 1994. Similarly, adult lizards increased in density (18 to 54/ha) because of good reproduction in 1993, but juveniles declined (154 to 21/ha) as reproduction was reduced in 1994. The introduced annual grass *Bromus tectorum* continued to spread below 5000 feet, though it remained at low density in comparison to its dominant congener, *Bromus rubens*. Hantavirus infection in rodents was monitored at townsites and widespread natural areas on the NTS. Carriers of the Muerto Canyon virus were limited to the deer mouse, (*Peromyscus maniculatus*), of which 4 of 31 tested positive for antibodies. The horse population declined 14 % to 56 animals in 1994. Deer sighting rates in 1994 were only 50 % of the 1993 level. Raptor populations in the spring of 1994 were somewhat higher than in the spring of 1993. Disturbance studies were conducted at eight sites - four areas blasted by above-ground nuclear weapons tests in the 1950s, the Sedan below-ground cratering test, a drill pad on Pahute Mesa, a revegetated waste-cleanup site, and a rodent-denuded area. Regardless of mechanism of`' disturbance, density of winter annuals was greater (mean 23 times) and biomass was greater (mean 31 times) wherever shrubs had been removed and their live volume remained low. On the T4 blast area and the revegetated site, where shrub live volume exceeded 90 % of control values, winter annual densities and biomass were not different from controls. Perennial plant populations remained much reduced on several blast areas, and recovery there was slower than on burned areas and roadsides. Small mammal densities on the blast areas were equivalent to controls. However, there were fewer species on the blast areas, which were dominated by the kangaroo rat (*Dipodomys merriami*). The lower diversity on the blast areas was hypothesized to be due to the reduced shrub cover. Densities of *D. merriami* were always greater on the blast areas, but those of other species were reduced. Lizard populations on the blast areas were dynamic. In spring, densities were similar to those on control plots, but in summer they were reduced, with juveniles reduced more than adults. Lizards were generally larger on the blast areas, but survival from spring to summer was reduced. The reduced lizard survival was also tentatively associated with the absence of shrubcover. Measurement of tritium in four fresh horse feces confirmed the presence of low, innocuous levels found in one sample in 1993. Tritium concentrations in grass samples collected from within the horse range suggested grass, rather than drinking water, may be the source of the tritium. *Keywords*: perturbations*, annual plants*, perennial plants*, reptile*, bird*, mammal*, ecology/ecosystem*, life history*

329 HUNTER, R.B. 1999. Competition between *Bromus madritensis rubens* and native desert annuals in the Northern Mojave Desert. In: The Desert Tortoise Council Proceedings of 1997-1998 Symposia, pp. 22-33. Desert Tortoise Council, Inc., Wrightwood, CA.

Bromus madritensis rubens invaded the Mojave Desert in the early 1900's and now dominates the winter annual population through much of the middle elevations. On the Nevada Test Site two *Bromus* removal experiments were performed to see if native species' populations would rebound. In the first experiment, when *Bromus* was selectively harvested from small quadrats early in the growing season, the native annual average weight was increased, but not to a statistically significant degree. There was no effect in the succeeding year. In the second experiment, 100 m^2 plots were sprayed with a grass-specific herbicide (fluazifop) where *Bromus* was dense. Again, native population densities increased where *Bromus* was reduced, but results were not statistically significant for several years. In three plots the weight of natives per square meter increased significantly in one, the density of natives increased in two, and number of species per quadrat increased significantly in two. The high spatial and temporal variability of native annual populations was a serious impediment to demonstrating that *Bromus* was reducing native populations. However, certain species appeared more severely affected. In shaded conditions under shrubs *Cryptantha pterocarya* and *Phacelia vallis-mortae* seemed more seriously inhibited. Larger annual species increased on sprayed plots, and may (as *Bromus*) require the more fertile soil under shrubs to mature. Those species included *Rafinesquia neomexicana*, *Chaenactis stevioides* and *Malacothrix glabrata*. Future experiments should focus on particular species, in particular habitats, and should continue for long time periods. (Author) *Keywords*: invasive species*, annual plants, ecology/ecosystem*

330 HUNTER, R.B., and P.D. GREGER. 1986. Desert Water Balance Using a Combination of Psychrometric and Resistance Sensors. In: Proceedings of the Rainfall Simulator Workshop January 14-15, 1985, Tucson, AZ. Lane, L.J. (Ed.). Society for Range Management, Denver, CO, pp. 30-34.

A combination of psychrometric and electrical resistance soil moisture instruments was used to determine water contents on irrigated plots in the northern Mojave Desert. The combination allowed determination of moisture contents between essentially saturation (30%) and a dryness below plant availability (4<%). The technique was well suited to determination of the nearsurface moisture dynamics which involved roughly two-thirds of the applied water. Preliminary results with the technique demonstrated that vegetation removal reduced soil drying rates, but removal of surface rocks had little effect. (Authors) *Keywords:* perturbations*, hydrology*, soil property*, vegetation*, methods*

331 HUNTER, R.B., and K.B. HUNTER. 1985. Effect of High Light Intensity on Mohave Desert Annuals: Comparison of Laboratory and Field Results. CIC 0083203, University of California, Los Angeles, 18 pp.

Light saturation curves and photosynthetic rates were measured in the laboratory for four Mohave Desert species - *Camissonia claviformis*, *C. brevipes*, *Caulanthus lasiophyllus*, and the introduced grass *Bromus rubens*. In conjunction with these experiments mirrors were placed in the field to increase sunlight intensities on natural Mohave Desert winter annual populations. Laboratory photosynthetic rates saturated at two to four times full sunlight intensities of photosynthetically active radiation in the three native species, while the introduced *B. rubens* photosynthesis saturated at roughly half of full sunlight. In the field, however, no increase in growth was apparent with added light, either of plants growing in shaded environments or of those growing in full sunlight. However, *B. rubens* located on the northeast sides of shrubs (morning light, afternoon shade) grew faster than those on the northwest edges when mirrors were present. Added light did not affect average density (survival), population size, or individual plant size in 1983, but in 1984 the highest light intensities appeared to cause premature death of *Camissonia claviformis*. These data suggest laboratory light saturation curves are not directly applicable to field plants. (Authors) *Keywords:* climate*, invasive species*, annual plants*, life history*, ecology/ecosystem*

332 **HUNTER, R.B., and P.A. MEDICA. 1989. Status of the Flora and Fauna on the Nevada Test Site, Results of Continuing Basic Environmental Research January through December 1987. DOE/NV/10630-2, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, 114 pp.**

This report describes initial efforts to monitor the status of the flora and fauna of the Nevada Test Site. A series of sites were established to study ephemeral and perennial plants, small mammals, and reptiles. Three pristine sites were established in undisturbed areas and two sites in burned areas. Study sites were sampled for total perennial species as measured on belt transects, cover, plant density and plant biomass. On the study plots there was a total of 29 perennial species measured. Cover varied 22 to 38 percent on the pristine sites and 1 to 3 percent on the burned sites. Biomass ranged from 3,010 to 5,580 kg dry wt/ha on pristine sites and from 40 to 127 kg dry wt/ha on burned areas. Plant density varied from one to four plants per square meter. The most common ephemeral species was *Bromus rubens* and introduced species. Six lizards were recorded on the four plots sampled in 1987. The most common species were *Uta stansburiana* (10-33 adults and 50-123 hatchlings/ha) and *Cnemidophorus tigris* (2-6 adults/ha). Ten species of small mammals were captured on four plots. The most common species were *Perognathus longimembris* (18-101/ha), *Dipodomys merriami* (12-4/ha), and *Dipodomys microps* (4-12/ha). (Authors) *Keywords:* climate*, perturbations*, invasive species*, annual plants*, perennial plants*, reptile*, mammal*, ecology/ecosystem*

333 **HUNTER, R.B., and P.A. MEDICA. 1992. Extent of land disturbance on the Nevada Test Site. In: Status of the Flora and Fauna on the Nevada Test Site, 1988. Hunter, R.B. (Compiler), DOE/NV/10630-29, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 3-7.**

The types of disturbance considered here include burned areas resulting from lightning-initiated fires or man-caused fires; blast zones from nuclear tests radex areas (radiation exclusion areas contaminated by radiation from above-ground nuclear testing); alpha radex areas; waste disposal areas; subsidence craters, drill pads and cable runs; base camp facilities and staging areas; roads (paved and unpaved), pre-emplacement test holes; and drill pads and tests which have not cratered. The area estimates (Table 1.1) are approximations based upon maps and best-guess estimates by personnel who are familiar with the NTS. Fires were approximated by NTS Fire Chief Ray Gudeman, at the time of each fire. Though crude in accuracy, these estimates represent the best available figures as of January 1988. Table 1.1 has associated notes that list the sources (maps, guesses, and measurements made from maps) for the area estimations. (Authors) *Keywords:* perturbations*, vegetation*

334 **HUNTER, R.B., E.M. ROMNEY, and A. WALLACE. 1980. Fencing Enhances Shrub Survival and Growth for Mojave Desert Revegetation. Great Basin Naturalist Memoirs No. 4:212-215.**

Fourteen species of native shrub were transplanted to bare areas of the northern Mojave Desert in 1972 and 1973. By 1978 plants surrounded by small fences were larger (0.26 vs 0.11 m^3 overall average for several species) and survived better (42 percent versus 23 percent) than unfenced plants. These effects are primarily due to reduced grazing of shoots. Loss of shrubs to pocket gophers or other burrowing rodents was not prevented by fencing. (Authors) *Keywords:* perturbations*, perennial plants*, mammal*, ecology/ecosystem*, life history*, revegetation*

335 **HUNTER, R.B., E.M. ROMNEY, and A. WALLACE. 1980. Rodent-denuded Areas of the Northern Mojave Desert. Great Basin Naturalist Memoirs 4:208-211.**

Populations of pocket gophers and rabbits regulate or control the perennial vegetation on relatively large sites in the northern Mojave Desert. Above-ground shoots are pruned and whole plants are killed by complete cutting of main roots. (Authors) *Keywords:* perturbations*, perennial plants*, mammal*, ecology/ecosystem*, nutrition/diet*

336 **HUNTER, R.B., E.M. ROMNEY, and A. WALLACE. 1982. Nitrate Distribution in Mojave Desert Soils. Soil Science 134(1):22-30.**

Extensive sampling shows high variability in nitrate concentration within profiles of Mojave Desert soils. This high variability greatly complicates studies of desert soil N and its ecological role. Patterns in nitrate distribution suggest effects of litter decomposition under shrubs, surface leaching in bare mass, and plant uptake in the wet zone. Two mechanisms proposed to explain high concentrations found at seemingly random depths are concentration at drying fronts and distribution along water potential gradients. (Authors) *Keywords:* soil property*, vegetation*, nutrition/diet*, ecology/ecosystem*

337 **HUNTER, R.B., E.M. ROMNEY, and A. WALLACE. 1987. Revegetation on Disturbed Desert Land at NUWAX and SEDAN. 1987. In: The Dynamics of Transuranics and Other Radionuclides in Natural Environments (Howard, W.A., and R.G. Fuller, Eds.). U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV. NVO-272, pp. 79-97.**

Natural restoration of shrubs and perennial grasses was investigated on desert land that had been disturbed by surface blading at the NUWAX site in west Jackass Flats and by the SEDAN nuclear cratering event located in northern Yucca Flat. Results from a 5-year study at NUWAX disclosed that new sprouts from sheared-off root systems, plus naturally occurring seedlings, can play an important role in the revegetation of disturbed desert land if steps are taken to prevent their destruction by grazing jackrabbits. At the SEDAN site, some isolated populations of *Atriplex canescens* have become established around host shrubs that survived the initial blast and radiation damage. Also, some new specimens of *Hymenoclea salsola* and *Lycium andersonii* shrubs have become established in downslope drainage systems near the outer boundary of the disturbed area. Aside from this, there has been virtually no natural restoration of shrubs within the area disturbed by blast, radiation, and throw-out since the SEDAN nuclear cratering event in 1962. During the past decade however, a succession to grassland involving the perennial grasses, *Oryzopsis hymenoides*, *Sitanion jubatum*, and *Stipa speciosa*, has occurred on disturbed land where throw-out overburden was less than 10 cm deep. (Authors) *Keywords:* perturbations*, perennial plants*

338 **HUNTER, R.B., A. WALLACE, and E.M. ROMNEY. 1976. Nitrogen transformations in Rock Valley and adjacent areas of the Mojave Desert. US/IBP Desert Biome Res. Memo. 76-28. Utah State University, Logan, 10 pp.**

This progress report summarizes additional investigations concerning the nitrogen cycle in the northern Mohave Desert. A point transact method was used to estimate lichen crust cover. Lichen crust covers only a very small part of the northern Mohave Desert and could account for much less than 1 kg/ha of fixed nitrogen per year. Free-living organisms may be more important. Acetylene reduction studies were continued. Findings of other years in relationship to specific plant species were not always reproducible. The semisymbiotic and rhizosphere nitrogen fixation appeared to be very irregularly distributed. Nitrogen applied one year previously was not found as mineral nitrogen in the soil surface in the subsequent analysis. Soil nitrate analyses for five different shrub clumps and adjacent bare areas were determined periodically (about three-week intervals) for a year at three different soil depths (0-7.5, 7.5-15, 15-22.5 cm). The values consistently decreased with depth and generally were highest in the March-April period, although the December-February period was almost as high. These results indicate that sufficient nitrogen is mineralized to meet the needs of plant growth in the spring. *Ambrosia dumosa* was used as a test plant to determine yearly changes in nitrogen concentrations. The rate of turnover of nitrogen in litter measured by plant uptake of various kinds was studied when ^{15}N-containing plant materials had been incorporated in soil. Considerable differences were observed for different kinds of plant material. Field plots were established to study nitrogen transfer rates and movement using ^{16}N as a tracer. Isotope ratio techniques were used to estimate soil pools of nitrogen and the root space for a given plant. All studies reported are being continued. (Authors) *Keywords:* IBP*, soil property*, microbiota*, perennial plants*, nutrition/diet*

339 **HUNTER, R.B., A. WALLACE, and E.M. ROMNEY. 1978. Persistent Atrazine Toxicity in Mohave Desert Shrub Communities. Journal of Range Management 31(3):199-203.**

Atrazine (11.2 kg/ha active ingredient) was applied in 1967 and 1968 to three areas of the northern Mohave Desert to destroy perennial shrub cover. Of the 23 perennial species 12 were completely eliminated. Two species, Mohave Yucca (*Yucca schidigera*) and big galleta (*Hilaria rigida*) showed no effects. Plants of creosote bush (*Larrea tridentata*), Nevada Ephedra (*Ephedra nevadensis*), and range ratany (*Krameria parvifolia*) were severely damaged but many survived through crown sprouting. Scattered plants of the invading species shadscale (*Atriplex confertifolia*), desert alyssum (*Lepidium fremontii*), and Russian thistle (*Salsola paulsenii*) became established by 1975 on the fertile mounds under killed shrubs. Glasshouse tests of seedling survival on soils sampled eight years after treatment showed 65 to 95% mortality, as compared to 3 to 8% mortality on control soils. (Authors) *Keywords:* perturbations*, invasive species*, annual plants*, perennial plants*, ecology/ecosystem*

340 **HUNTER, R.B., A. WALLACE, and E.M. ROMNEY. 1979. Nitrogen transformations in Rock Valley and adjacent areas of the Mojave Desert. US/IBP Desert Biome Res. Memo. 77-22. Utah State University, Logan, 19 pp.**

This is the final report of investigations of nitrogen transformations in the northern Mohave Desert areas adjacent to Rock Valley. Harvests and tissue analyses of *Ambrosia dumosa* showed that within measurement limits all nitrogen required for growth of leaves and new stems during 1975 was derived from soil pools. Although nitrogen in leaves ranged from 0 to 40%

of N in live above-ground tissues, it was not depleted from stems or large roots in spring, nor accumulated in them as dormancy approached. Variations in *Ambrosia* leaf and stem concentrations of other elements during 1975 were also measured. A buildup of soluble salts in leaves suggested that they act as wicks after capillary flow of water to roots ceased. Nitrogen in ^{15}N-tagged plant material added to Rock Valley soils was more available to plants than endogenous soil nitrogen. A half-life of three to four years for this added nitrogen was indicated by soil analysis and plant uptake. Loss solely through harvest would result in a half-life of seven to eight years under glasshouse conditions. Treatment of selected shrub clumps with ^{15}N fertilizer allowed estimates of root zone radii varying from less than one to more than 7 m for common Mohave Desert shrubs. Labeling of plant tissues occurred primarily in new leaves, stems and fruit, and all soil analyses showed $^{15}NO_3^-$ remained in the nitrate form 70 days after application. Extensive measurements of acetylene reduction indicated a near absence of nitrogen fixation associated with random samples of soils, litter or roots of major shrub species. A seasonal trend of ethylene production by roots was found. Evolution of ethylene from litter and adsorption of ethylene and acetylene by dry soils were indicated. Soils amended with fertilizers and incubated under the field under three watering regimes showed ammonia volatilization, nitrification, denitrification and organic matter decomposition to be slow processes under Mohave Desert conditions. Input of ammonium and nitrate by rainfall amounted to approximately 2 kg N/ha in 1976. Three samples of cemented gravel from the undersides of buried rocks contained 306, 398 and 621 µg $N0_3^-$ N/g of acid-soluble "cement." (Authors) *Keywords:* IBP*, soil property*, microbiota*, perennial plants*, nutrition/diet*, physiology*

341 **HUNTER, R.B., A. WALLACE, and E.M. ROMNEY. 1980. Field Studies of Mineral Nutrition of *Larrea tridentata*: Importance of N, pH, and Fe. Great Basin Naturalist Memoirs 4:163-167.**

Multivariate analysis of soil and plant data from the northern Mojave Desert was used to investigate aspects of the mineral nutrition of *Larrea tridentata* (Sesse & Moc. ex DC.) Cov. *Larrea tridentata* biomass was significantly correlated with soil NO_3^- and pH and leaf Fe content. Leaf canon accumulation was negatively correlated with leaf Fe concentration. (Authors) *Keywords:* soil property*, perennial plants*, nutrition/diet*, ecology/ecosystem*

342 **HUNTER, R.B., E.M. ROMNEY, J.D. CHILDRESS, and J.E. KINNEAR. 1975. Responses and interactions in desert plants as influenced by irrigation and nitrogen applications. US/IBP Desert Biome Res. Memo. 75-13. Utah State University, Logan, 7 pp.**

Residual effects of sprinkle irrigation on Mohave Desert shrub communities from 1968 through 1970 were observed, as were initial effects of trickle irrigation performed in 1974. The sprinkle-irrigated plots showed a residual increase in density of four species, but many others either failed to reproduce in significant numbers or lost all gains made during the dry years following treatment. Response to trickle irrigation was similarly species-dependent with just a few endemic species responding strongly to water. Invasion by short-lived perennials and summer annuals was begun, but was not massive during the initial season. Above-ground productivity, due mainly to established shrubs, varied from 52 to 560 kg/ha on dry control plots and from 1,726 to 2,130 kg/ha on irrigated plots. Nitrogen requirements for above-ground growth were 1 to 7 kg/ha on dry plots and 31 to 39 kg/ha on irrigated plots. Soil nitrate levels were strongly elevated by 100 kg N/ha applied as NH_4NO_3. Ammonium concentrations quickly decreased to control levels on irrigated plots, but remained high after fertilization of dry plots during the unusually dry summer of 1974. Mineral and nitrogen contents of leaves were little affected by nitrogen fertilization or irrigation during the initial season of treatment in contrast to effects on plants grown in a greenhouse. The primary phenological effect of treatment was to extend the period of growth of stems and leaves of those shrubs not normally inhibited by high soil and air temperatures. (Authors) *Keywords:* IBP*, annual plants*, perennial plants*, nutrition/diet*, life history*, ecology/ecosystem*

343 **HUNTER, R.B., E.M. ROMNEY, A. WALLACE, and J.E. KINNEAR. 1980. Residual Effects of Supplemental Moisture on the Plant Populations of Plots in the Northern Mojave Desert. Great Basin Naturalist Memoirs 4:24-27.**

Residual effects of sprinkle irrigation from 1968-1970 on populations of Mojave Desert shrub communities were observed in late 1974. The sprinkle-irrigated plots showed a residual increase in density of four species, but other species either failed to reproduce in significant numbers or lost all gains made during the years following treatment. The seven-year change for the irrigated plots was equivalent to a gain of 1,178 perennial plants per ha, but the nonirrigated plots lost an average of 1,050 plants per ha equivalent during the same period. The biomass gain after seven years was equivalent to 1,000 kg/ha for irrigated plots and 310 for nonirrigated plots. (Authors) *Keywords:* hydrology*, vegetation*, ecology/ecosystem*

344 **HUNTER, R., A. WALLACE, E.M. ROMNEY, and P.A.T. WIELAND. 1975. Nitrogen Transformations in Rock Valley and Adjacent Areas of the Mohave Desert. US/IBP Desert Biome Res. Memo. 75-35, Utah State University, Logan, UT, 8 pp.**

This progress report contains findings from studies of rates of change in the nitrogen compartments of desert soils and vegetation. An analysis of the upper 90-cm profile of soil, which was given surface applications of nitrogen in 1968 and 1970, showed that the fertilizer nitrate still remained in the root zone of plots receiving only natural rainfall. The concentrations frequently reached high levels and varied from place to place in the profiles. In contrast, the fertilizer nitrate essentially had disappeared (by 1974) from the root zone in plots given supplemental moisture by sprinkler irrigation. These results have possible implications on the denitrification process under Mohave Desert conditions. Soluble ammonium recoverable from fertilizer application decreased rapidly after wetting. Nitrogen requirements for above-ground productivity were lower than 10 $kg{\cdot}ha^{-1}{\cdot}yr^{-1}$ in both Rock Valley (1973) and Mercury Valley (1974). Acetylene reduction activity in the root zone of individual perennial shrubs was found to be highly variable. The number of species showing this activity was quite large and included several very common species, including *Larrea tridentata* and *Bromus rubens*. Cation-nitrogen balances in leaves differed significantly among species and may reflect soil conditions. Finally, collection of available data suggests nitrogen pool sizes are generally adequately known, but turnover rates and rates of input and loss have been inadequately studied. (Authors) *Keywords:* IBP*, soil property*, invasive species*, annual plants*, perennial plants*, nutrition/diet*, physiology*

345 **HUNTER, R.B., M.B. SAETHRE, P.A. MEDICA, P.D. GREGER, and E.M. ROMNEY. 1991. Biological Studies in the Impact Zone of the Liquefied Gaseous Fuels Spill Test Facility in Frenchman Flat, Nevada. DOE/NV/10630-15. Reynolds Electrical & Engineering Co. Inc., Las Vegas, NV.**

Desert shrubs and rodents were monitored downwind of the Department of Energy Liquefied Gaseous Fuels Spill Test Facility (LGF), which is situated on a dry lake bed (playa). Plants were censussed in 1981 and 1986 through 1990; rodent survival was measured from 1986 through 1990. During that time there were no apparent effects of the spill tests on animals or plants off the edge of the playa, which extends more than 2.5 kilometers from the facility. Plant populations increased in volume from 1981 through 1986, then declined precipitously during a drought in 1989 and 1990. Rodent populations also declined during the drought. Some effects of spilled hydrogen fluoride gas were seen on plants growing on manmade mounds on the playa surface. Animal and bird species seen in the vicinity of the LGF are also reported. (Authors) *Keywords:* climate*, perturbations*, vegetation*, bird*, reptile*, mammal*, ecology/ecosystem*

346 **HUNTER, R.B., E.M. ROMNEY, A. WALLACE, H.O. HILL, T.L. ACKERMAN, and J.E. KINNEAR. 1976. Responses and interactions in desert plants as influenced by irrigation and nitrogen applications. US/IBP Desert Biome Res. Memo. 76-14. Utah State University, Logan, 7 pp.**

Effects of trickle irrigation and 25 or 100 kg N/ha applied as NH_4NO_3 were studied in Mercury Valley, adjacent to Rock Valley. During 1975, shrub growth continued at a more rapid pace in irrigated plots than in nonirrigated plots, but vegetative production shifted from new stem growth toward proportionally greater production of deciduous structures. Fewer new shrub seedlings germinated and survived in 1975 than in 1974. Both irrigation and nitrogen treatments increased the numbers and biomass of winter annuals (primarily the grasses *Bromus rubens* and *Festuco octoflora*). Biomass on irrigated and fertilized plots was 342 kg/ha vs. 141 kg/ha on the controls. Summer annuals were nearly absent from each of the plots in 1975. Seed production was studied in the major shrub species. Irrigation increased fruit production per plant in all species; nitrogen increased it in some and decreased it in others. *Ambrosia dumosa* fruit production was reduced almost 50% by 100 kg N/ha, and *Larrea tridentata* fruit production was little affected by either irrigation or nitrogen. (Authors) *Keywords:* IBP*, hydrology*, invasive species*, annual plants*, perennial plants*, life history*, ecology/ecosystem*

347 **HUNTER, R.B., E.M. ROMNEY, A. WALLACE, J.E. KINNEAR, T.L. ACKERMAN, and H.O. HILL. 1979. Responses and interactions in desert plants as influenced by irrigation and nitrogen applications. US/IBP Desert Biome Res. Memo. 77-11. Utah State University, Logan, 14 pp.**

Effects of 20 cm trickle irrigation and 25 or 100 kg N fertilizer were followed for the third year. Biomass changes were minimal; an apparent equilibrium having been reached in which all water is used for maintenance production. Complex interactions of irrigation, time of irrigation and nitrogen fertilization were noted in several species. Winter annuals were increasingly dominated by *Bromus rubens*, and dicot winter annual numbers were reduced on irrigated plots. The grass *Schismus arabicus* strongly increased in population as both a winter and a summer annual on irrigated plots. Residual nitrate from the February 1974 application of 100 kg N/ha was approximately 15 kg/ha on irrigated and 60 kg/ha on unirrigated plots. Soil electrical conductivity approached 2 mmho/cm on several plots, indicating a moderate salt buildup associated with irrigation and fertilization. Shrub seed and winter annual grass nitrogen contents, and correlations of shrub mineral analyses with irrigation and nitrogen parameters, are discussed. Phenological effects of irrigation on *Ambrosia dumosa*, *Larrea tridentata* and *Acamptopappus shockleyi* are reported. Some species responded more to winter irrigation, while others responded to summer irrigation. (Authors) *Keywords:* IBP*, invasive species*, annual plants*, perennial plants*, nutrition/diet*, life history*, ecology/ecosystem*

348 **HUXMAN, T.E., and S.D. SMITH. 1999. Photosynthesis, water use and growth of a desert annual and ephemeral at the Nevada Desert FACE Facility. In: Symposium Abstracts, The Ecological Society of America 84th Annual Meeting, August 8-12, 1999, Spokane, WA.**

Patterns of plant gas exchange have been well documented in growth chamber, glasshouse, and open-top chamber elevated CO_2 experiments, all which manipulate microenvironment, potentially dictating plant function. For this reason, gas exchange in species from an intact ecosystem, under normal environmental factors and elevated CO_2 is critical to ultimately understand ecological consequences of rising CO_2. We evaluated the gas exchange patterns of both *Bromus madritensis* spp. *rubens* and *Eriogonum inflatum* over a complete life cycle (establishment to flowering) at the Nevada Desert FACE Facility (NDFF). Life history stage significantly affected the pattern of photosynthetic enhancement to elevated CO_2 seasonally, through adjustments in the functional response of the photosynthetic apparatus. Transient patterns of down-regulation to elevated CO_2 resulted in stage-specific patterns of carbon gain throughout the season, occurring in a species-specific manner. Elevated CO_2 reduced stomatal conductance to a greater degree in *Eriogonum* than in *Bromus*. *Bromus* showed photosynthetic enhancement by elevated CO_2 throughout diurnal periods, whereas *Eriogonum* only had greater rates when stomatal closure restricted photosynthesis at midday for ambient plants. These gas exchange patterns highlight the importance of experiments that use intact ecosystems with little disturbance and the importance of placing gas exchange results in the context of life history stages and biomass accumulation periods. (Authors) *Keywords:* FACE*, perturbations*, invasive species*, annual plants*, life history*, physiology*

349 **HUXMAN, T.E., and S.D. SMITH. 2001. Photosynthesis in an invasive grass and native forb at elevated CO_2 during an El Niňo year in the Mojave Desert. Oecologia (In press).**

Annual and short-lived perennial plant performance during wet years is important for long-term persistence in the Mojave Desert. Additionally, the effects of elevated CO_2 on desert plants may be relatively greater during years of high resource availability compared to dry years. Therefore, during an El Niño year at the Nevada Desert FACE Facility (a whole-ecosystem CO_2 manipulation), we characterized photosynthetic investment (by assimilation rate-internal CO_2 concentration relationships) and evaluated the seasonal pattern of net photosynthesis (A_{net}) and stomatal conductance (g_s) for an invasive annual grass, *Bromus madritensis* ssp. *rubens* and a native herbaceous perennial, *Eriogonum inflatum*. Prior to and following flowering, *Bromus* showed consistent increases in both the maximum rate of carboxylation by Rubisco (V_{Cmax}) and the light-saturated rate of electron flow (J_{max}) at elevated CO_2. This resulted in greater A_{net} at elevated CO_2 throughout most of the life cycle and a decrease in the seasonal decline of maximum midday A_{net} upon flowering as compared to ambient CO_2. *Eriogonum* showed significant photosynthetic down-regulation to elevated CO_2 late in the season, but the overall pattern of maximum midday A_{net} was not altered with respect to phenology. For *Eriogonum*, this resulted in similar levels of A_{net} on a leaf area basis as the season progressed between CO_2 treatments, but greater photosynthetic activity over a typical diurnal period. While g_s did not consistently vary with CO_2 in *Bromus*, it did decrease in *Eriogonum* at elevated CO_2 throughout much of the season. Since the biomass of both plants increased significantly at elevated CO_2, these patterns of gas exchange highlight the differential mechanisms for increased plant growth. The species-specific interaction between CO_2 and phenology in different growth forms suggests that important plant strategies may be altered by elevated CO_2 in natural settings. These results indicate the importance of evaluating the effects of elevated CO_2 at all life cycle stages to better understand the effects of elevated CO_2 on whole-plant performance in natural ecosystems. (Authors) *Keywords:* FACE*, perturbations*, climate*, invasive species*, annual plants*, life history*, physiology*

350 **HUXMAN, T.E., E.P. HAMERLYNCK, and S.D. SMITH. 1999. Reproductive allocation and seed production in *Bromus madritensis* ssp. *rubens* at elevated atmospheric CO_2. Functional Ecology 13:769-777.**

Two trends are consistent across the response of plant species to growth at elevated CO_2: decreased leaf nitrogen content and increased photosynthetic gas exchange. While both of these are very important to the understanding of plant and ecosystem responses to climate change, little research has evaluated the consequences of these patterns on reproductive allocation and seed production. For this reason, *Bromus madritensis* ssp. *rubens* was grown in ambient (360 μ mol mol^{-1}), x 1·5 ambient (550 μmol mol^{-1}) and elevated (700 μmol mol^{-1}) CO_2 environments to compare the relationship between allocation to growth and reproduction as a function of CO_2 growth environment. There were no differences in final total biomass or reproductive mass between CO_2 growth environments. There were significant decreases in reproductive mass per unit total mass and per unit vegetative mass, but not per unit leaf surface area (LSA), as growth CO_2 environment increased from 360 to 700 μmol mol^{-1} CO_2. Despite these decreases, the number of seeds produced per unit LSA in elevated CO_2 significantly increased as compared to ambient CO_2. These results may be owing to a shift in allocation to greater investment in vegetative growth as compared to reproduction under elevated levels of atmospheric CO_2. Prior to reproduction, there were no significant differences between CO_2 treatments in carbon uptake by leaves. In contrast, plants grown in elevated CO_2 did not show a decline in photosynthetic rate during seed filling, suggesting that nitrogen may not have been re-translocated from leaves to seeds as apparently occurred in ambient plants. Patterns measured here may partially explain the parental effect of CO_2 environment exhibited in *Bromus*. Seeds produced from elevated parental CO_2 growth conditions lead to seedlings that produce smaller leaves that are delayed in development and smaller roots as compared to structures produced by seeds from ambient-grown parents. Because the success of *Bromus* is partially owing to its ability to produce large numbers of viable seeds, these changes in reproductive allocation and subsequent seedling performance with respect to growth in an elevated CO_2 environment may have impacts on community composition in the Mojave Desert. (Authors)
Keywords: FACE*, perturbations*, invasive species*, annual plants*, physiology*

351 HUXMAN, T.E., T. CHARLET, C. GRANT, and S.D. SMITH. 2001. The effects of parental CO_2 and offspring nutrient environment on initial growth and photosynthesis in an annual grass. International Journal of Plant Science (In press).

Seeds of *Bromus madritensis* ssp. *rubens* (red brome, an exotic annual grass in the Mojave Desert), from parents grown at three CO_2 levels (360, 550, and 700 μmol mol^{-1}), were grown in factorial CO_2 (360, 550, and 700 μmol mol^{-1}) and nutrient (zero addition, 1 : 40-strength, and 1 : 10-strength Hoagland's solution) environments to evaluate parental CO_2 effects on offspring performance characteristics across a range of developmental environments. We evaluated growth rate, leaf nitrogen content, and photosynthetic gas exchange over a 3-wk period. Seedlings from elevated-CO_2 parental seed sources (2 x AMB seedlings) had reduced growth rates compared with seedlings from ambient CO_2-grown parents (AMB seedlings). As compared to 360, 550 and 700 μmol mol^{-1} CO_2-stimulated relative growth rate (RGR) for most seedlings, the degree of stimulation was greatest for the AMB seedlings and least for the 2 x AMB seedlings. Instantaneous rates of photosynthesis mirrored the pattern of RGR across the parental CO_2 and seedling CO_2 treatment combinations. At 360 μmol mol^{-1} $CO_{2,}$ photosynthetic rates of 2 x AMB seedlings were half that of AMB seedlings, but at 700 μmol mol^{-1} CO_2, their photosynthetic rates were not statistically different. Analysis of A-C_i response curves indicates that 2 x AMB seedlings had reduced Rubisco activity compared with AMB seedlings, most likely as a result of less total nitrogen investment in leaves. AMB seedlings responded to low levels of nutrient input (1 : 40 Hoagland's solution) with increased growth rates and leaf nitrogen content compared with zero nutrient addition. The 2 x AMB seedlings required the application of 1 : 10 Hoagland's before an increase in these two parameters, compared with zero nutrient addition. These results indicate that elevated CO_2 affects *Bromus* offspring performance through changes in adult-seed-seedling nitrogen dynamics, such that reductions in photosynthesis and growth rates occur in successive generations. Species-specific allocation patterns that increase or decrease nitrogen allocation to seeds may enhance or diminish the ability of subsequent offspring to respond to an elevated CO_2 environment. (Authors) *Keywords:* FACE*, perturbations*, invasive species*, annual plants*, nutrition/diet*, physiology*, life history*

352 HUXMAN, T.E., E.P. HAMERLYNCK, M.E. LOIK, and S.D. SMITH. 1998. Gas exchange and chlorophyll fluorescence responses of three southwestern *Yucca* species to elevated CO_2 and high temperature. Plant, Cell & Environment. 21:1275-1283.

The ability of seedlings to tolerate temperature extremes is important in determining the distribution of perennial plants in the arid south-western USA, and the manner in which elevated CO_2 impacts the ability of plants to tolerate high temperatures is relatively unknown. Whereas the effects of chronic high temperature (30-38 °C) and elevated CO_2 are comparatively well understood, little research has assessed plant performance in elevated CO_2 during extreme (> 45 °C) temperature events. We exposed three species of *Yucca* to 360 and 700 μmol CO_2 mol^{-1} for 8 months, then 9 d of high temperature (up to 53 °C) to evaluate the impacts of elevated CO_2 on the potential for photosynthetic function during external high temperature. Seedlings of a coastal C_3 species (*Yucca whipplei*), a desert C_3 species (*Yucca brevifolia*), and a desert CAM species (*Yucca schidigera*), were used to test for differences among functional groups. In general, *Yuccas* exposed to elevated CO_2 showed decreases in carboxylation efficiency as compared with plants grown at ambient before the initiation of high temperature. The coastal species (*Y. whipplei*) showed significant reductions (33%) in CO_2 saturated maximum assimilation rate (A_{max}), but the desert species (*Y. brevifolia* and *Y. schidigera*) showed no such reductions in A_{max}. Stomatal conductance was lower in elevated CO_2 as compared with ambient throughout the temperature event; however, there were species-specific differences over time. Elevated CO_2 enhanced photosynthesis in *Y. whipplei* at high temperatures for a period of 4 d, but not for *Y. brevifolia* or *Y. schidigera*. Elevated CO_2 offset photoinhibition (measured as F_v/F_m) in *Y. whipplei* as compared with ambient CO_2, depending on exposure time to high temperature. Stable F_v/F_m in *Y. whipplei* occurred in parallel with increases in the quantum yield of photosystem II ($\Phi PSII$) at high temperatures in elevated CO_2. The value of $\Phi PSII$ remained constant or decreased with increasing temperature in all other treatment and species combinations. (Authors) *Keywords:* FACE*, perturbations*, perennial plants*, physiology*

353 HUXMAN, T.E., E.P. HAMERLYNCK, D.N. JORDAN, K.L. SALSMAN, and S.D. SMITH. 1998. The effects of parental CO_2 environment on seed quality and subsequent seedling performance in *Bromus rubens*. Oecologia. 114(2):202-208.

Seeds were collected and compared from parent plants of *Bromus rubens* L. (Poaceae), an exotic Mojave Desert annual grass, grown in ambient (360 µmol mol^{-1}) and elevated (700 µmol mol^{-1} CO_2, to determine if parental CO_2, growth conditions affected seed quality. Performance of seeds developed on the above plants was evaluated to determine the influence of parental CO_2, growth conditions on germination, growth rate and leaf production. Seeds of *B. rubens* developed on parents grown in elevated CO_2, had a larger pericarp surface area, higher C:N ratio, and less total mass than ambient-developed seeds. Parental CO_2, environment did not have an effect on germination percentage or mean germination time, as determined by radicle emergence. Seedlings from elevated-CO_2-developed seeds had a reduced relative growth rate and achieved smaller final mass over the same growth period. Elevated-CO_2- developed seeds had smaller seed reserves than ambient seeds as determined by growing seedlings in sterile media and monitoring senescence. It appears that increased seed C:N ratios associated with plants grown under elevated CO_2, may have a major effect on seed quality (morphology nutrition) and seedling performance (e.g., growth rate and leaf production). Since the invasive success of *B. rubens* is primarily due to its ability to rapidly germinate, increase leaf area and maintain a relatively high growth rate compared to native annuals and perennial grasses, reductions in seed quality and seedling performance in elevated CO_2, may have significant impacts on future community composition in the Mojave Desert. (Authors) *Keywords:* FACE*, perturbations*, invasive species*, annual plants*, nutrition/diet*, life history*

354 HUXMAN, T.E., E.P. HAMERLYNCK, B.D. MOORE, S.D. SMITH, D.N. JORDAN, S.F. ZITZER, R.S. NOWAK, J.S. COLEMAN, and J.R. SEEMANN. 1998. Photosynthetic down-regulation in *Larrea tridentata* exposed to elevated atmospheric CO_2: Interaction with drought under glasshouse and field (FACE) exposure. Plant, Cell & Environment 21:1153-1161.

The photosynthetic response of *Larrea tridentata* Cav., an evergreen Mojave Desert shrub, to elevated atmospheric CO_2 and drought was examined to assist in the understanding of how plants from water-limited ecosystems will respond to rising CO_2 We hypothesized that photosynthetic down-regulation would disappear during periods of water limitation, and would, therefore, likely be a seasonally transient event. To test this we measured photosynthetic, water relations and fluorescence responses during periods of increased and decreased water availability in two different treatment implementations: (1) from seedlings exposed to 360, 550, and 700 µmol mol^{-1} CO_2 in a glasshouse; and (2) from intact adults exposed to 360 and 550 µmol mol^{-1} CO_2 at the Nevada Desert FACE (Free Air CO2 Enrichment) Facility. FACE and glasshouse well-watered *Larrea* significantly down-regulated photosynthesis at elevated CO_2, reducing maximum photosynthetic rate (A_{max}), carboxylation efficiency (CE), and Rubisco catalytic sites, whereas droughted *Larrea* showed a differing response depending on treatment technique. A_{max} and CE were lower in droughted *Larrea* compared with well-watered plants, and CO_2 had no effect on these reduced photosynthetic parameters. However, Rubisco catalytic sites decreased in droughted *Larrea* at elevated CO_2. Operating C_i increased at elevated CO_2 in droughted plants, resulting in greater photosynthetic rates at elevated CO_2 as compared with ambient CO_2 In well-watered plants, the changes in operating C_i, CE and A_{max} resulted in similar photosynthetic rates across CO_2 treatments. Our results suggest that drought can diminish photosynthetic down-regulation to elevated CO_2 in *Larrea*, resulting in seasonally transient patterns of enhanced carbon gain. These results suggest that water status may ultimately control the photosynthetic response of desert systems to rising CO_2. (Authors) *Keywords:* FACE*, perturbations*, perennial plants*, physiology*

355 JENSEN, P., and M.M. HOOTEN. 2000. Burrowing Depths of Ant Species of the Transition Desert and Pinon-Juniper Plant Communities of the Nevada Test Site. Neptune and Company, Inc., Document Number 05100-02.

The authors describe the ant species which are likely found in both the Transition desert and Pinon-Juniper plant communities of the NTS and report the maximum burrowing depths for each of the species. They conclude that the maximum depth to which ants will burrow in the region of the NTS is five meters. (CAW) *Keywords*: invertebrate*, ecology/ecosystem*

356 **JOHNSON, M.S., and D.E. HIBBARD. 1957. Geology of the Atomic Energy Commission Nevada proving grounds area, Nevada. USGS Bull. 1021-K, 55 pp.**

The Nevada proving grounds area in Nye and Clark Counties, Nev., is about 700 square miles in size and lies about 70 miles northwest of Las Vegas in southern Nevada. It consists essentially of two large valleys, Yucca and Frenchman Flats, both surrounded and separated from one another by hills and mountains of variable relief. Seventeen Paleozoic formations and one of Tertiary age have been recognized in the Nevada proving grounds area. The Paleozoic formations are Early Cambrian to probable early Permian in age and consist of 22,000 feet of limestone, dolomite, quartzite, shale, and conglomerate beds. The predominantly volcanic Oak Springs formation of Tertiary age is at least 2,000 feet thick and is the most widespread formation in the area. A granitic intrusion of probable Late Cretaceous to early Tertiary age has metamorphosed and mineralized some of the Paleozoic rocks, and dikes of middle Tertiary or later age occupy normal faults along the northeastern margin of the area. Quaternary deposits reaching a maximum thickness of more than 800 feet are mostly a heterogeneous mixture of detritus derived from bedrock areas. This fill contains some caliche and fanglomerates. Playas made up wholly of impermeable fine silt and clay are present. During the Mesozoic era uplift and attendant folding and contemporaneous thrust faulting occurred, probably in Cretaceous time. Normal faulting began in early Tertiary time, followed by volcanic deposition and later by continued normal fault displacement. (Authors) *Keywords:* geology*

357 **JOHNSON, R.F., C.S. COOK, L.A. WEBB, and R.L. MATHER. 1958. Neutron-induced radioactive isotopes in soils (Operation Teapot, Project 2.3a). WT-1117, 53 pp.**

A report is given on the part of Project 2.3 that studied the activities induced in the surface of the earth near Ground Zero (GZ) by neutrons released from a nuclear detonation. Gamma ray spectral measurements of Nevada Test Site soil obtained from the vicinity of GZ following Shots 1, 4 and 7 were studied. From these it is concluded that the relative quantities of observed neutron-induced activity to fission fallout activity are functions of height, yield, and type of detonation. Ten different soil samples were exposed to the neutrons from Shot 5. While only Na-24 and Mn-56 activities could be definitely found in significant quantities in all soils, the relative amounts of these two radioisotopes varied over a considerable range and, within reasonable accuracy, can be said to have been activated in proportion to the amount of sodium and manganese atoms present in the soil at the time of irradiation. (Authors) *Keywords:* radionuclide inventory*, soil property*

358 **JORDAN, D.E., S.F. ZITZER, G.R. HENDREY, K.F. LEWIN, J. NAGY, R.S. NOWAK, S.D. SMITH, J.S. COLEMAN, and J.R. SEEMANN. 1999. Biotic, abiotic and performance aspects of the Nevada Desert free-air CO_2 enrichment (FACE) facility. Global Change Biology 5:659-668.**

Arid and semiarid climates comprise roughly 40% of the earth's terrestrial surface. Deserts are predicted to be extremely responsive to global change because they are stressful environments where small absolute changes in water availability or use represent large proportional changes. Water and carbon dioxide fluxes are inherently coupled in plant growth. No documented global change has been more substantial or more rapid than the increase in atmospheric CO_2. Free Air CO_2 Enrichment (FACE) technology permits manipulation of CO_2 in intact communities without altering factors such as light intensity or quality, humidity or wind. The Nevada Desert FACE Facility (NDFF) consists of three 497.m^2 plots in the Mojave Desert receiving 550 µL L^{-1} CO_2 and six ambient plots to assess both CO_2 and fan effects. The shrub community was characterized as a *Larrea-ambrosia-Lycium* species complex. Data are reported through 12 months of operation. (Authors) *Keywords:* FACE*, perturbations*, climate*, vegetation*, life history*, physiology*, methods*

359 **JORDAN, D.N., C. BIGGART, S.F. ZITZER, L.A. DEFALCO, and R.S. NOWAK. 1999. Interaction of leaf conductance and soil water availability of three native Mojave Desert species exposed to Free Air CO_2 Enrichment (FACE). In: Symposium Abstracts, The Ecological Society of America 84th Annual Meeting, August 8-12, 1999, Spokane, WA.**

Leaf stomatal conductance has been widely predicted to decrease with increasing concentrations of atmospheric CO_2 However, it is possible that under extreme moisture limitation, stomatal control may be insensitive to environmental CO_2. In a dry Mojave Desert community, three native perennial plants representing three different physiological forms were measured monthly for two, consecutive years during their periods of physiological activity. One of the years was wet, and total precipitation of 327 mm exceeded the 25-yr record, but the other was more representative of the long-term average of 140 mm/yr. *Larrea tridentata* C_4 evergreen shrub), *Pleuraphis rigida* (C_4 grass), and *Achnatherum hymenoides* (C_4 grass) were maintained within the Nevada Desert FACE Facility (NDFF) in ambient atmospheric CO_2 (~360 µL/L CO_2) or elevated (550 µL/L CO_2). The FACE experiment was established in an existing community without disturbing the research plots. The plants within the FACE research plots were all mature prior to initiation of the experiments, but conductance measurements were made during the second and third growth seasons of treatment. Seasonal and diurnal interactions with CO_2 treatment were observed in all species, with greatest responsiveness of conductance to CO_2 treatment associated with higher soil moisture availability, and low responsiveness with dry soils or temperature limitations. Decreases in stomatal conductance were observed at elevated CO_2 under optimum growth conditions in both C_4 and C_4 plants. (Authors) *Keywords*: FACE*, perturbations*, perennial plants*, physiology*

360 JORGENSEN, C.D. 1962. Disturbance of mammal traps by jack rabbits. Great Basin Naturalist Memoirs 22:83-86.

When the disturbance of Young-type mammal traps by hares became a serious threat to the collection of rodent data, the trapping pattern was altered to determine their reactions and behavior as a prerequisite to their removal from the study area. Following this sequence of experiments, the following theories are presented: (1) the hares responded to the bait inside the trap rather than the trap itself, (2) their visual senses enabled them to detect traps with accessible bait and avoid traps with inaccessible bait, (3) they followed trails to search which was suggestive of a learning process. (BBM) *Keywords:* mammal*, ecology/ecosystem*

361 JORGENSEN, C.D. 1963. Notes on the biology and distribution of *Paracotalpa granicollis* Haldeman (Coleoptera: Scarabaeidae). Pan-Pacific Entomologist 39:154-156.

Certain aspects of the biology and distribution of *Paracotalpa granicollis* were observed at the Nevada Test Site. Adult males were observed flying in all the plant communities except Pinyon-Juniper. They were most numerous in the *Grayia-Lycium* and *Lycium* communities and least numerous in the *Coleogyne* and *Artemisia* communities. They preferred sandy bajada soils, but not sandy washes or gullies. Males were observed from January to April. Mating behavior was discussed. (HP) *Keywords:* vegetation*, invertebrate*, life history*, ecology/ecosystem*

362 JORGENSEN, C.D. 1963. Spatial and time distribution of *Dipodomys microps occidentalis* within distinct plant communities. Ecology 44:183-187.

Two factors in animal distribution were evident: (1) a distinct border effect resulting from the trapping technique, (2) variations in distribution resulting from a continuous death rate opposing a seasonal birth rate. (HP) *Keywords:* vegetation*, mammal*, ecology/ecosystem*

363 JORGENSEN, C.D. 1967. A new species of Tuckerella (Acarina: Tuckerellidae) from Nevada. Entomol. News 78:141-146:

Females, males, and nymphs of a new species of Tuckerella were collected from *Coleogyne ramosissima, Atriplex canescens,* and *Atriplex confertifolia* at the Nevada Test Site. This is the only species known to be native to North America. (HP) *Keywords:* perennial plant*, invertebrate*, taxonomy*

364 JORGENSEN, C.D. 1968. Home range as a measure of probable interactions among populations of small mammals. Journal of Mammalogy 49:104-112.

A technique for estimating the probability of interaction in space using the home range as a basis of measurement is presented. The overlap area between adjacent home ranges and the relative use of home range area are used to obtain the estimate. The methods were demonstrated with data for *Perognathus longimembris* for the USAEC (U.S. Atomic Energy

Commission) Nevada Test Site. Probable interaction between females ranged from 0.6301 for individuals with recapture centers only 11.43 m apart to 0.0000 for animals 88.53 m apart. In this case the recapture radius was 44.45 m. Probable interaction between males and females ranged from 0.6289 to 0.0000 with distances from recapture centers of 11.43 m to 85.53 m, respectively. Assumptions required by this technique and limitations of interpretation are discussed. (Author) *Keywords:* mammal*, ecology/ecosystem*

365 **JORGENSEN, C.D. 1968. Spatial relationships of *Perognathus longimembris* (Coues) in southern Nevada. Proceedings: Utah Academy of Sciences, Arts and Letters 45:118-125.**

The spatial relationships of least pocket mice were evaluated at Nevada Test Site using the home range and distance between nearest neighbors. Generally, there was a clear ranking of classes within the population, some being much more tolerant of other classes than others, although there was considerable overlap. This ranking behavior could effect such parameters as sex ratios, relative survival rates, etc. which are vital in understanding population growth. (HP) *Keywords:* mammal*, ecology/ecosystem*, life history*

366 **JORGENSEN, C.D. 1970. Free living mites of the Nevada Test Site. (Final Report) USAEC Report COO-1731-4, 46 pp.**

The effects of nuclear weapons testing on the species composition and distribution of mites in the Nevada Test Site area were studied. Sampling sites are described and a map is presented to show the location. A table is presented to show average beta and gamma radiation levels at various locations within the sampling sites. Methods of collecting mites from vegetation are described and mathematical formulas for determining ratios of predaceous, phytophagous, and scavenger mites are presented. Seventeen phenotypically distinct groups of mites were identified and a table is presented to show numbers of mites in each group for all samples taken. Graphs are presented to show species diversity indices at various sites; the effect of radiation stress, primarily beta, was to increase the species diversity. The effects of radiation stress on trophic level organization are indicated by means of graphs that show ratios of predaceous mites to phytophagous and scavenger forms. A list is presented of 111 plant species from which mites were collected and a list of approximately 400 species of mites collected is presented. (HLW) *Keywords:* radionuclide inventory*, invertebrate*, methods*, ecology/ecosystem*, taxonomy*, radiation*

367 **JORGENSEN, C.D., and C.L. HAYWARD. 1963. Notes on shrews from southern Nevada. Journal of Mammalogy 44:582.**

Three species of shrews were collected at the Nevada Test Site. All collections were made with sunken can traps. (HP) *Keywords:* mammal*, ecology/ecosystem*, taxonomy*

368 **JORGENSEN, C.D., and C.L. HAYWARD. 1965. Mammals of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 6(3), 81 pp.**

Two primary aspects of small mammal distribution at the Nevada Test Site are particularly evident. The occurrence of species in relation to elevation changes and the changing fauna as the ecotone is transected between the Mohave Desert and Great Basin Desert. A transect between the Mohave Desert and the Great Basin Desert crosses several valleys where any one species may occupy several functional or spatial niches. Examples of this are *Grayia spinosa* and *Lycium andersonii*, which are identified as a distinct biotic community in Yucca Flat, but are scattered among communities typified by other species in Frenchman Flat. *Dipodomys* may be used to interpret the ecotone between the Great Basin desert, and the Mohave Desert, and *Perognathus* may be used to interpret the physiognomy within the valleys resulting from habitat changes. (HP) *Keywords:* vegetation*, mammal*, ecology/ecosystem*, taxonomy*

369 **JORGENSEN, C.D., and A.M. ORTON. 1962. Note of lizards feeding on oatmeal bait. Herpetologica 17:278.**

The animals caught in Young-type live traps are named. Stomach analysis revealed lizards ate oatmeal bait while confined inside. (HP) *Keywords:* reptile*, ecology/ecosystem*

370 **JORGENSEN, C.D., and W.W. TANNER. 1963. The application of the density probability function to determine the home ranges of *Uta stansburiana stansburiana* and *Cnemidophorus tigris tigris*. Herpetologica 19:105-115.**

Purposes of this paper are to estimate the home range of *Uta stansburiana stansburiana* Baird and Girard and *Cnemidophorus tigris tigris* Baird and Girard and to discuss the application of two methods for determining home range. The minimum polygon and density probability function methods were applied, and the latter gave results closer to those expected from field observations. The home ranges were: *Uta stansburiana* juveniles 16.82 ares (.42 acres), adult females 27.36 ares (.68 acres), and adult males 39.30 ares (.98 acres); *Cnemidophorus tigris* juveniles 21.7 ares (.54 acres), adult females 51.15 ares (1.28 acres), and adult males 28.65 ares (.71 acres). Trapping space, collection methods, trapping period, animal behavior, and methods of estimation must be considered in the interpretation of home range. In this study, normal distribution gave an estimate which more closely approximated the observed distribution than did Pearson's incomplete gamma distribution. (BBM) *Keywords:* reptile*, ecology/ecosystem*, methods*

371 **JORGENSEN, C.D., D.M. ALLRED, and D.E. BECK. 1963. Some effects of an underground nuclear detonation on biotic communities at the Nevada Test Site. Proceedings: Utah Academy of Sciences, Arts and Letters 40:49-61.**

The Brigham Young University study group found two major vegetation zones which extended from Sedan ground zero to about 3,250 feet. It was characterized by *Salsola kali, Sitanion hansenii, Oryzopsis hymenoides* and *Mentzelia albicaulis*. The second shrub zone was mde up primarily of *Coleogyne ramosissima*, *Grayia spinosa,* and *Lycium andersonii*. These are the plants which originally covered the entire area before nuclear testing began in 1951. After the test, vegetation from ground zero to 3,000 feet was destroyed and more than a foot of throw-out was deposited. From 3,000 to 5,000 feet the vegetation was damaged by flying missiles. No visible blast damage occurred to plants beyond 5,000 feet except for a dust layer. The area where drastic changes of populations of small mammal survivors was noted was between 4,000 and 5,000 feet. Beyond 5,000 feet the populations were not reduced by the blast or throw-out effects. The disturbance did not cause an immediate movement of small mammals away from the area of destruction. (HP) *Keywords:* perturbations*, vegetation*, invasive species*, annual plants*, perennial plants*, mammal*, radiation*

372 **JORGENSEN, C.D., A.M. MORTON, and W.W. TANNER. 1963. Voice of the leopard lizard, *Crotaphytus wislizenii* Baird and Girard. Proceedings: Utah Academy of Sciences, Arts and Letters 40:115-116.**

Buried can traps have been used frequently to study invertebrates and lizards at the U.S. Atomic Energy Commission Nevada Test Site. While operating the traps in a *Grayia spinosa-Lycium andersonii* plant community in Sept. 1961, a leopard lizard was discovered with a high pitched voice. This distinct squeal-like voice replaces the usual hissing sound which is characteristic of the species after it has been excited. The lizard (a female) was returned to the laboratory where its voice was recorded on tape to be presented during this discussion. Particular note was made of all leopard lizards collected from the test site during the next year and only rarely was one found that would not squeal when excited. The nature of the voice is difficult to characterize, although it sounded similar to that of the western banded geckos (*Coleonyx variegatus*) Baird which have been collected from the test site. Some leopard lizards responded with no apparent period of agitation necessary, but most required a period of excitement before the characteristic hissing was replaced by squealing. After they had squealed for one to three minutes, a vicious attack on the object of agitation usually resulted, and a rest period was necessary before the voice was again discernible. The lizards were more easily induced to squeal in the early morning than later in the day. To our knowledge, this is the first record of a distinct voice for this species. Stebbins (Amphibians and Reptiles of Western North America: 201, 1954) stated that only a few lizards have a voice. He does not include the leopard lizard as one of these. Since the majority of the individuals collected at the Nevada test site after the first voice was discovered, squealed, it was concluded to be a characteristic of the species in this area. (Authors) *Keywords:* vegetation*, perennial plants*, reptile*, ecology/ecosystem*

373 **KAAZ, H.W., A. WALLACE, and E.M. ROMNEY. 1971. Effect of a chronic exposure to gamma radiation on the shrub *Ephedra nevadensis* in the northern Mojave Desert. Radiation Botany 11: 33-37.**

A 33,600 Ci ^{137}Cs source which was differentially shielded to increase the uniformity of the distribution of radiation was set up on a 15-m tower in the center of a 9-ha plot in Jan. 1964 in the Rock Valley areas of the northern Mojave Desert. In the spring of 1969 the large majority of 5000 *Ephedra nevadensis* Wats. shrubs (Mormon tea) within the plot failed to produce flowers and very little vegetative growth occurred on the species in contrast to a control plot and to other nonirradiated areas. The 5-yr cumulative radiation exposure throughout about 85% of the plot ranged from 3.9 to 9.8 kR. Radiation effects on other species were nonexistent or doubtful. *E. nevadensis* has a higher interphase chromosome volume than do the other shrub species. (Authors) *Keywords:* perennial plants*, life history*, radiation*

374 **KANTZ, A.D. 1971. Measurement of beta dose to vegetation from close-in fallout. In: (Bensen, D.W., and A.H. Sparrow, Eds.) *Survival of Food Crops and Livestock in the Event of Nuclear War,* AEC Symposium Series 24 (CONF-700909), pp. 56-70.**

Dosimetry experiments are described in which both beta and gamma ray doses to the environment and to vegetation were measured with thermoluminescent dosimetric techniques in the close-in fallout fields from the Plowshare cratering events Cabriolet and Schooner. The beta doses measured were found to be an order of magnitude greater than the gamma-ray doses at the same location. This work was performed in support of ecological- and environmental- effects studies sponsored by the Environmental Sciences Branch of the Atomic Energy Commission's Division of Biology and Medicine. (Author) *Keywords:* vegetation*, radiation*

375 **KARL, A.E. 1989. Yucca Mountain Project: Investigations of Desert Tortoise Abundance and Distribution on the Focused Baseline Study Area, Fall 1989 Field Studies. Environmental Science Associates, Inc., San Francisco, CA.**

This report documents the field studies of desert tortoises that were conducted in Fall 1989 in the Focused Baseline Study Area (FBSA) within the Yucca Mountain Project Area. The objectives of thes studies were to collect baseline data on the distribution of tortoises and to obtain estimates of abundance. Studies were also structured to provide data for construction of a preliminary analysis of impacts to the local tortoise population from previous and planned DOE activities, as well as to model appropriate future study projects on this tortoise population. The study was conducted in two phases. The first was a walking and driving reconnaissance of the FBSA to map habitat quality for tortoises. The second involved walking 23 strip transects to assess distribution, habitrat associations, and relative abundance of tortoises. The greatest amount of the total sign, 70.3%, was found on the alluvial fans, 4.7% on the gently slopes of ridge remnants surrounding the fans, and 25% on the ridge remnant/drainage mosaic of steep hillsides on the east side of Yucca Mountain. Sign was found in all vegetation communities, but largely in or bordering creosote bush-dominated areas of the recent alluvial fans. The data suggest that densities are probably between approximately 10 and 50 tortoises/mi^2. The highest densities seem to occur in the alluvial fans of the eastern FBSA. Densities in the steep ridge remnants of the west are probably lower, perhaps 10 tortoises/mi^2. The author compares her data to data previously collected for DOE. (Author) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*

376 **KIEFT, T.L, W.P. KOVACIK, and J. TAYLOR. 1996. Factors Limiting Microbial Activity in Volcanic Tuff at Yucca Mountain. LA-SUB–96-105, Los Alamos National Laboratory, Los Alamos, NM.**

Samples of tuff aseptically collected from 10 locations in the Exploratory Shaft Facility at the site of the proposed high-level nuclear waste repository at Yucca Mountain, Nevada Test Site were analyzed for microbiological populations, activities, and factors limiting microbial activity. Radiotracer assays ({sup 14} C-labeled organic substrate mineralization), direct microscopic counts, and plate counts were used. Radiolabeled substrates were glucose, acetate, and glutamate. Radiotracer experiments were carried out with and without moisture and inorganic nutrient amendments to determine factors limiting to microbial activities. Nearly all samples showed the presence of microorganisms with the potential to mineralize organic substrates. Addition of inorganic nutrients stimulated activities in a small number of samples. The presence of viable microbial communities within the tuff has implications for transport of contaminants. (Authors) *Keywords:* YMSCO*, geology*, microbiota*, ecology/ecosystem*, nutrition/diet*

377 **KIEFT, T.L, W.P. KOVACIK, D.B. RINGELBERG, D.C. WHITE, D.L. HALDEMAN, P.S. AMY, and L.E. HERSMAN. 1997. Factors limiting microbial growth and activity at a proposed high-level nuclear repository, Yucca Mountain, Nevada. Applied and Environmental Microbiology 63(8):3128-3133.**

As part of the characterization of Yucca Mountain, Nev., as a potential repository for high-level nuclear waste, volcanic tuff was analyzed for microbial abundance and activity. Tuff was collected aseptically from nine sites along a tunnel in Yucca Mountain. Microbial abundance was generally low: direct microscopic cell counts were near detection limits at all sites (3.2×10^4 to 2.0×10^5 cells g^{-1} [dry weight]); plate counts of aerobic heterotrophs ranged from 1.0×10^1 to 3.2×10^3 CFU g^{-1} (dry weight). Phospholipid fatty acid concentrations (0.1 to 3.7 pmol g^{-1}) also indicated low microbial biomasses;

diglyceride fatty acid concentrations, indicative of dead cells, were in a similar range (0.2 to 2.3 pmol g^{-1}). Potential microbial activity was quantified as $^{14}CO_2$ production in microcosms containing radiolabeled substrates (glucose, acetate, and glutamic acid); amendments with water and nutrient solutions (N and P) were used to test factors potentially limiting this activity. Similarly, the potential for microbial growth and the factors limiting growth were determined by performing plate counts before and after incubating volcanic tuff samples for 24 h under various conditions: ambient moisture, water-amended, and amended with various nutrient solutions (N, P, and organic C). A high potential for microbial activity was demonstrated by high rates of substrate mineralization (as much as 70% of added organic C in 3 weeks). Water was the major limiting factor to growth and microbial activity, while amendments with N and P resulted in little further stimulation. Organic C amendments stimulated growth more than water alone. (Authors) *Keywords:* YMSCO*, geology*, microbiota*, nutrition/diet*, ecology/ecosystem*

378 KILLPACK, M.L., and M.A. GOATES. 1963. Bat captured in snap trap. Journal of Mammalogy 44:125-126.

A female pallid bat, *Antrozous pallidus pallidus* (LeConte) was caught 8 July 1961 in a Museum Special snap trap at the Nevada Atomic Test Site, Mercury, Nye County, Nevada. The trap was one of 50 in a line established to collect small rodents. Traps were spaced 30 ft apart and baited with a combination of wet and dry rolled oats. The bat was trapped in the open near a sagebrush, *Artemisia tridentata* Nutt., on the floor of a small canyon near the base of Rainier Mesa. Here sandstone cliffs make up part of the slopes where pinyon pine and junipers extend down to the edge of the sagebrush community. Shrubs of this latter community range from 6 to 15 inches in height with an average spacing of 2 to 3 feet. The bat apparently had alighted before being caught. Its wings were folded in a resting position, and it was secured across the center of the body with its head facing away from the treadle of the trap. Apparently it had sighted an insect on or near the trap, and was caught when attempting to secure it. Such a collection of the pallid bat is not unlikely when the habits of this species are considered. Hall (Mammals of Nevada, Univ. Calif. Press, p. 165, 1946) noted that this bat flies low over vegetation while searching for food, occasionally alighting on the bole of trees. Burt (San Diego Soc. Nat. Hist., 7:397, 1934) listed it as being a low flyer, even alighting on the ground to capture June beetles. Grinnell (Univ. Calif, Publ. Zool., 1918) found remains of Jerusalem crickets on the floor of a cave where pallid bats had been roosting. Our observation lends additional evidence that this species seeks some of its food on the ground. This observation was made as part of a study under AEC Contract AT (11-1)786. (Authors) *Keywords:* perennial plants*, mammal*, ecology/ecosystem*, nutrition/diet*

379 KLEIN, W.L., and R.A. BRECHBILL. 1972. Preliminary radiation surveillance of an aquatic system near the Nevada Test Site, June-July, 1967. SWRHL-65r, 23 pp.

Results of a three-month preliminary radiation surveillance study of an aquatic system in Upper Pahranagat Lake near the Nevada Test Site are presented. The study was conducted to determine the concentrations of fission products in selected samples and to establish the necessary methodology for radiation surveillance in an aquatic ecosystem. Radionuclide concentrations were found to be insignificant in water, aquatic plant, and fish samples. Sediment samples had detectable levels of ^{137}Cs, ^{40}K, ^{90}Sr, and U. Strontium-90 levels in fishbone were low (2.38 pCi/g bone ash) compared with those found in bovine femur samples (6.9 pCi/g bone ash) collected during the same period. (Authors) *Keywords:* EPA*, hydrology*, wetlands*, vegetation*, radionuclide inventory*, fish*, mammal*, radiation*

380 KLEINKOPF, G.E., T.L. HARTSOCK, A. WALLACE, and E.M. ROMNEY. 1980. Photosynthetic strategies of two Mojave Desert shrubs. Great Basin Naturalist Memoirs (4):100-109.

Photosynthetic production of two Mojave Desert shrubs was measured under natural growing conditions at UCLA. Measurements of photosynthesis, transpiration, resistances to water vapor flux, soil moisture potential, and tissue water potential were made. *Atriplex canescens* (Pursh) Nutt., a member of the C_4 biochemical carbon dioxide fixation group was highly competitive in growth rate and production during conditions of adequate soil moisture. As soil moisture conditions declined to minus 40 bars, the net photosynthetic rate of *Atriplex* decreased to zero. However, the C_3 shrub species *Larrea tridentata* (Sesse & Moc. ex DG) Cov. was able to maintain positive net photosynthetic production during conditions of high temperature and extreme low soil moisture through the major part of the season. The comparative advantages of the C_4 versus the C_3 pathway of carbon fixation was lost between these two species as the soil moisture potential declined to minus 40 bars. Desert plants have different strategies for survival, one of the strategies being the C_4 biochemical carbon fixation pathway. However, many of the plants are members of the C_3 group. In this instance, the C_4 fixation pathway does not confer an added advantage to the productivity of the species in the Mojave Desert. Species distribution based on comparative photosynthetic production is discussed. (Authors) *Keywords:* soil property*, perennial plants*, physiology*

381 **KNIGHT, H.H. 1968. Taxonomic review: Miridae of the Nevada Test Site and the Western United States. Brigham Young University Science Bulletin, Biological Series 9(3), 282 pp.**

Approximately 5,000 specimens of plant bugs were collected at the Nevada Test Site between 1959 and 1965. A total of 160 species representing 50 genera was taken at the site. Of these, 7 genera and 96 species were new to science. Comparative data for these and other western species were included. Taxonomic keys to subfamilies, genera, and species, distribution data and host plant relationships are provided. (HP) *Keywords:* vegetation*, invertebrate*, ecology/ecosystem*, taxonomy*

382 **KORANDA, J.J. 1969. Residual tritium at Sedan Crater. In: Nelson, D.J., and F.C. Evans (Eds.) Symposium on Radioecology, Proceedings of the Second National Symposium on Radioecology (CONF-670503), pp. 696-708.**

Residual tritium from the Sedan thermonuclear detonation, 6 July 1962, was scavenged by or entrained in the 5-6 million tons of earth materials moved by the detonation. As a result, the Sedan postshot environment contained a most significant biological tracer in the form of THO. Residual tritium (THO) is found in uCi concentrations in the interstitial water of the Sedan throwout soil, and in the loose tissue water of plants which have re-invaded the new substratum deposited on the landscape adjacent to the crater. Tritium is present not only in the loose tissue water of vascular plants growing on the Sedan throwout, but a comparable level is also found in the tissue-bound hydrogen of these plants. Herbivores, mainly heteromyid rodents, which have re-invaded the Sedan post-shot environment and reside there, also have tritium concentrations in their body water between 1 and 3 uCi/ml. These body-water tritium concentrations are closely related to the levels of tritium in the plant tissue-bound hydrogen. Soil-water tritium concentrations in the soil air at the rodent burrow depth are several orders of magnitude lower than the observed body-water level. The inspirational route of entry of tritium into the animal is therefore assumed to be a secondary one, with the primary source being the plant organic matter synthesized in the Sedan post-shot environment which is used as the animal's food base. The internal dose to the resident mammal at Sedan crater from residual tritium is estimated to be between 18 and 268 rads, or about 10 times that from external radiation sources resulting from the detonation. (Author) *Keywords:* perturbations*, radionuclide inventory*, vegetation*, mammal*, radiation*

383 **KORANDA, J.J., and J.R. MARTIN. 1969. The persistence of radionuclides at sites of nuclear detonations. In: (Shore, B., and F. Hatch, CoChrs.) *Biological Implications of the Nuclear Age*, Proceedings of the Symposium held at Livermore, CA, March 1969 (CONF-690303), pp. 159-187.**

A study of the persistence of radioisotopes at nuclear detonation sites is extremely important for evaluating future peaceful engineering uses of nuclear explosions such as the excavation of canals and harbors. Information on the distribution of radioisotopes at test detonation sites (Pacific Proving Ground and Nevada Test Site), where earth has been moved to create craters or trenches, was studied and the uptake of certain radioisotopes by plants and animals in the areas was examined. Sedan Event data on tritium concentrations in crater fallback, crater soil water, tissue water of plants growing on ejecta, and kangaroo rats living in the Sedan area are presented. Five years after the shot, tritium was found to be the most abundant radioisotope in ejecta or in any biological system in the area. (LCL) *Keywords:* perturbations*, radionuclide inventory*, vegetation*, mammal*, radiation*

384 **KORANDA, J.J., J.R. MARTIN, and R. WIKKERINK. 1967. Residual tritium at Sedan crater. Part 2. Soil and Ejecta Studies. USAEC Report UCRL-50360, 42 pp.**

Continuing studies of residual tritium in soil or ejecta deposited on the landscape around the Sedan crater, Nevada Test Site, are concerned with the spatial and temporal distribution of THO in the area from the crater lip to 5,000 ft from ground zero. Seasonal variations in the concentrations of tritium in soil water occur mainly during the winter rainfall period. Dilution effects were observed to a depth of 3 ft during an unusually high rainfall period (1965-1966). Diluted tritium concentrations in the surface strata of soil (6 in. to 3 ft) increase to almost the predilution levels during the summer as a result of soil moisture movements. When Sedan ejecta occurs as a shallow layer overlying the preshot soil, maximum tritium concentrations are found in this soil, usually at the maximum depth of rainfall penetration, or approximately 3 ft. Maximum concentration of tritium in ejecta on the Sedan crater lip is found at a depth of 4 to 5 ft and is correlated with the depth of ejecta materials found around the crater lip. An inventory of tritium in the Sedan ejecta field was calculated, based upon collections of soil samples along transects of the ejecta-covered area, and to a depth of 6 ft at each site. The tritium inventory measurements are essentially of biologically available water in the soil system. When data are corrected to total soil-water tritium values, the current inventory of tritium outside the Sedan crater in 1967, five years postshot, is 5 to 6% of the estimated inventory of the residual tritium in the ejecta at shot time. (Authors) *Keywords:* perturbations*, radionuclide inventory*

385 KORANDA, J.J., J.R. MARTIN, and R.W. WIKKERINK. 1970. Leaching of radionuclides at Sedan Crater. In: *Radionuclides in the Environment*, Advances in Chemistry Series, Number 93, pp. 97-117.

The distribution of tritium and long-lived gamma radioactivity was studied in crater ejecta from the Sedan detonation (July 1962). Tritium concentrations were determined in soil water extracted from crater ejecta samples collected from the surface to 6 feet, and at distances of 3,000 feet from the crater from 1966-1968. Tritium distribution was very obviously modified by postshot environmental effects, especially rainfall leaching. Tritium maximum concentrations were found below the strata in which they were deposited. Gamma radionuclides exhibited limited movement in the crater ejecta strata or in preshot soil covered by Sedan ejecta. A subtle leaching of Cs-137 was demonstrated by considering the Cs-137/Mn-54 ratios in the ejecta strata. (Authors) *Keywords:* perturbations*, radionuclide inventory*

386 KORANDA, J.J., J.R. MARTIN, R.W. WIKKERINK, and M.L. STUART. 1969. Radioecological studies. In: Bio-Medical Division Preliminary Report for Project Schooner (USAEC Report UCRL-50718), pp. 43-56.

See abstract #257, GRABSKE, R.J., and J.M. DAWSON. 1969. *Keywords:* radionuclide inventory*, vegetation*, invertebrate*, vertebrate*, mammal*, radiation*

387 KORANDA, J.J., J.R. MARTIN, R. WIKKERINK, and M. STUART. 1970. Postshot distribution and movement of radionuclides in nuclear crater ejecta. In: Proceedings of the American Nuclear Society Symposium on Engineering with Nuclear Explosives held in Las Vegas, NV, January 1970 (CONF-700101, Volume 1), pp. 400-421.

The distribution and postshot movement of radionuclides in nuclear crater ejecta are discussed. Continuing studies of tritium movement in ejecta at Sedan crater demonstrate that variations in tritium concentration are correlated with seasonal rainfall and soil water movements. Loss of 27 mCi $^{3}H/ft^{2}$ are evident on Sedan crater lip at the end of a three year period of measurements in which an unusually large flux of rain was received. The distribution of gamma emitting radionuclides and tritium is described in the recently created Schooner crater ejecta field. The specific activity of radionuclides in the Schooner ejecta continuum is shown for ejecta collected from the crater lip to 17 miles from Ground Zero (GZ). The movement of W-181 and tritium into the subejecta preshot soil is described at a site 3,000 feet from GZ. (Authors) *Keywords:* perturbations*, radionuclide inventory*

388 KORANDA, J.J., P.L. PHELPS, L.R. ANSPAUGH, and G. HOLLADAY. 1971. Sampling and analytical systems for measuring environmental radioactivity. In: *Rapid Methods for Measuring Radioactivity in the Environment (*IAEA-SM-148/36), pp. 587-614.

Rapid methods of sampling and quantitating airborne tritiated water, radioactive particulates and a wide range of environmental samples have been developed to document the releases of radioactivity associated with uses of nuclear explosives, reactor operation and basic radioecological studies. Two types of atmospheric water samplers have been used in environmental studies conducted in remote field operations. A simple cold-pipe sampler of several designs employing either LN or CO_2 has been used in laboratory studies and field studies. A more complex sampler which may eventually be actuated using a column of magnesium perchlorate or molecular sieve has also been used. A sampling and analytical system for determining air concentrations of radioactive particulates has been used successfully in several types of radioecological studies associated with nuclear cratering experiments, monitoring of worldwide and closein fallout deposition, and reactor studies. A series of automatically sequenced air pumps which draw air through an efficient fiberglass filter is the basic component of this flexible air sampling system. The system may be turned on by radiation levels or by other means. Filters are prepared in a standard geometry and sealed in containers which retain gaseous radioactivity. Air flow data are obtained by calibration of the air pump before and after sample collection. Automatic particle collection trays are also described. Micrometeorological instrumentation is placed in the field with the sequential air sampler and provides supplemental data on the movement of radioactive particulates in the environment. The sample is assayed with a solid-state detector and a 4,096-channel pulse height analyser. The high resolution of this spectrometer permits quantitating 10-20 radionuclides simultaneously. The use of this solid state spectrometer has been extended to in situ field measurements of deposited radioactivity. The mobile system is mounted in a small van with a portable power supply and transported to remote field sites for measurement of environmental radioactivity. Sample preparation techniques for a wide range of environmental samples including animal organs, vegetation, and soil are discussed. (Authors) *Keywords:* radionuclide inventory*, vegetation*, vertebrate*, radiation*, methods*

389 KRIEGER, H.L. 1965. The measurement of long-lived activation products in soil by gamma spectroscopy. Health Physics 11: 653-658.

Soil samples collected at the site of the 1957 balloon-type nuclear detonation in Nevada have been periodically analyzed to determine specific nuclides and to observe changes in spectrum configurations resulting from decay of the shorter lived gamma activities. In 1963, Cs-134, Co-60, Pu-52 and Pu-154 were separated by radiochemical analysis and identified by gamma spectrometry. Both manual stripping of the identified nuclides and matrix calculations, in which identical geometric configurations were used, corroborated the presence of these nuclides in the soil sample. Photopeaks of the induced short-lived Sc-46, which were evident in the 1957 spectrum, were not evident in the new gamma scan. No Sr-90, Cs-137 or other fission products were detected; all the nuclides present evidently were produced by neutron activation of their stable precursors. Repeated acid leaching removed only about 70 percent of the activities of the nuclides present, indicating a very strong attachment of these nuclides to the soil. Estimations of the relative individual activities were calculated by use of computer matrix solutions developed from calibrated standards. (Author) *Keywords:* radionuclide inventory*, methods*

390 LANE, L.J. 1987. Hydrologic Research at the Nevada Test Site. In: The Dynamics of Transuranics and Other Radionuclides in Natural Environments (Howard, W.A., and R.G. Fuller, Eds.). U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV. NVO-272, pp. 511-516.

Rainfall simulator studies on erosion plots have been made on rangelands in Arizona, Idaho, New Mexico, and Nevada. An extensive data base has been developed for various ecosystems in these western states and because the same simulator and similar experimental design were used for all the studies, results can be easily transferred across ecosystems. Results from these studies have been related to USLE parameters and to effects of various surface and canopy characteristics. The importance of erosion pavement on the erosion process of western arid and semiarid rangelands have been demonstrated and appears to be more dominant than vegetative canopy. (Author) *Keywords:* NAEG*, hydrology*, soil property*, vegetation*, ecology/ecosystem*

391 LANE, L.J., E.M. ROMNEY, and T.E. HAKONSON. 1984. Water Balance Calculations and Net Production of Perennial Vegetation in the Northern Mojave Desert. Journal of Range Management 37(1):12-18.

Measurements obtained between 1968 and 1976 indicate the influence of climatic factors and soil characteristics upon soil moisture and production of perennial vegetation in the northern Mojave Desert. Seasonal distribution patterns of precipitation are shown to have a strong effect on plant-available soil moisture, and these patterns are, in turn, reflected in net production of perennial vegetation. Available climatic data and soil characteristics were used as input to a continuous simulation model to calculate the water balance for a unit area watershed. Computed and measured soil moisture agreed quite well over a range of values from close to the wilting point to near field capacity. We used computed evapotranspiration rates to estimate water use by perennial vegetation. Computed water use was multiplied by a water use efficiency factor to estimate net production of perennial vegetation. Estimated net production exhibited year-to-year variability comparable with measured values, and agreed quite closely with available observations. This paper briefly describes soil-water-plants relationships in the northern Mojave Desert and illustrates an application of a continuous simulation model to predict soil moisture and net production of perennial vegetation. Base on our analysis, the simulation model would appear to have potential for estimating the water balance and above ground net primary production on arid and semiarid rangelands. (Authors) *Keywords:* climate*, hydrology*, soil property*, perennial plants*, ecology/ecosystem*, methods*

392 LARSON, K.H. 1959. Summary of observations of distribution, characteristics and biological availability of fallout originating from continental detonations. In: Biological and Environmental Effects of Nuclear War, Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, U.S. 86th Congress, 1st session, June 1959, pp. 803-830.

Describes progress made by the Environmental Radiation Division between 1949-1959 to: delineate fallout patterns and their characteristics as a result of nuclear testing; study the chemical, physical, and radiological characteristics of fallout debris; and to determine the biological availability, rate of accumulation, and retention of the fallout debris in various native and domestic plants and animals, as well as the persistence and redistribution of residual contamination in the total environment. (TPO) *Keywords:* radionuclide inventory*, vegetation*, vertebrate*, radiation*

393 **LARSON, K.H. 1963. Continental close-in fallout: its history, measurement and characteristics. In: (Schultz, V., and A.W. Klement, Jr., Eds.) *Radioecology*, Proceedings of the First National Symposium on Radioecology, pp. 19-26.**

Biological and radiological studies were made of the Trinity site. Vegetation appeared to be the most important influence in decreasing wind-borne radioactivity. The levels of beta activity in the surface in. of soil ranged from 60 to 380 disintegrations/min/gm or one pCi per sq ft 1 in. deep. Five years after the detonation there was evidence of downward migration of radioactivity into the second in. in Chupadera Mesa, but not in the crater. The radioactivity of plant material was 3.85 percent of soil radioactivity in 1949 and 5.6 percent in 1950. Tissue deposition was first detected in *Neotoma* sp. in the fourth year after detonation. Plutonium was found in amounts up to 0.07 ug/ per sq ft, one-half in. deep, at a distance 88 miles northeast of the Trinity site and 1.47 ug per sq ft was found 28 miles northeast of the site in Chupadera Mesa. (HP) *Keywords:* radionuclide inventory*, vegetation*, mammal*, radiation*

394 **LARSON, K.H. 1985. Continental Close-In Fallout - Its History, Measurement, and Characteristics. In: *The Radioecology of Transuranics and other Radionuclides in Desert Ecosystems - December 1982*. Howard, W.A., P.B. Dunaway, and R.G. Fuller (Eds.). NVO-224, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV.**

Included in this report are summary statements of significant findings related to the distribution, characteristics, and biological availability of fallout debris originating from testing programs at the Nevada Test Site during the past decade. The accumulation of radioiodine by native animals was observed to be a function of distance from ground zero. Radio-barium-140, Y-91, Sr-89, and Sr-90 were major bone contaminants. Post series sampling of native animals indicated that the accumulation of Sr-89 was also a function of distance from the point of detonation; however, the Sr-90 accumulation by animals correlated poorly with the strontium unit levels in soils. Observations during the past decade indicate that less than 10 percent of the total Sr produced from nuclear detonations at the Nevada Test Site (NTS) has been deposited within 200 miles from the point of detonation. (Author) (CAW) *Keywords:* NAEG*, radionuclide inventory*, vertebrate*, radiation*

395 **LARSON, K.H., H.A. HAWTHORNE, and J.H. OLAFSON. 1962. Nevada Test Site fallout: some characteristics, its apparent environmental equilibrium and biological availability. In: Klement, A.W., Jr. (Ed.) *Radioactive Fallout from Nuclear Weapons Tests*, USAEC Report TID-7632, Book 1, pp. 4-24.**

Fallout from the detonation of test devices at the Nevada Test Site is governed by many complex variables such as energy yield and type of device, wind structure, support used for the device, nature of the ground surface, contact of the fireball with ground surface, and mass of inert material surrounding the device. Findings are summarized on the distribution and characteristics of fallout from detonations of tower-mounted devices and from balloon-mounted or air-dropped devices having less than 75 kt yield. The environmental equilibrium and biological availability of fission products are considered with emphasis on Sr-90. Results of biological studies indicate that biological availability of Sr-90 is much greater at some early time after fallout and that mechanisms for the reduction of potentially available Sr-90 exist in the environment, regardless of apparently persistent Sr-90 soil levels. (CH) *Keywords:* radionuclide inventory*, vegetation*, vertebrate*, radiation*

396 **LARSON, K.H., J.H. OLAFSON, H.M. MORK, and D.R. HOWTON. 1952. Field observations and preliminary field data obtained by the UCLA survey group on Operation Jangle, November 1951. USAEC Report UCLA-182, 29 pp.**

Observations on each of the Operation Jangle detonations and preliminary data on the area contaminated by the fallout material are summarized. Estimated fallout patterns are suggested for each detonation based on counting at various sites. The first crop of radishes grown on contaminated soil absorbed a significant percentage of radioactivity. (WDM) Keywords: radionuclide inventory*, annual plants*, radiation*

397 **LARSON, K.H., J.W. NEEL, H.A. HAWTHORNE, H.M. MORK, R.H. ROWLAND, L. BAURMASH, R.G. LINDBERG, J.H. OLAFSON, and B.W. KOWALEWSKY. 1966. The behavior of fallout in the environment; Biotic availability of fallout debris to indigenous animals and plants. In: Distribution, Characteristics, and Biotic Availability of Fallout, Operation**

Plumbbob (WT-1488), pp. 118-181. UCLA, Los Angeles, CA.

Four persistence study stations were maintained on the midline of Priscilla fallout and two on the midline of Smoky fallout pattern. Maximum air temperature, minimum relative humidity, and maximum air movement occurred at about 1300 hours each day. Opposite measurements occurred at about 0300 hours. Wind speed was negligible at 6 inches above the soil surface as compared with speeds 36 inches above the soil surface in areas with normal to dense vegetation cover; wind speeds were approximately equal at the two measurement heights in areas having sparse vegetation. Radioactive decay measured in the field was similar to the decay of comparable fallout samples measured in the laboratory. Attenuation of gamma radiation was measured as 15.7 percent at 18 inches and 27.2 percent at 36 inches, of the radiation at one inch, using film badge type dosimeters. Beta attenuation similarly was measured as 28.6 percent at 18 inches and 44.2 percent at .36 inches, of the beta radiation measured at 1 inch above the soil surface. Fallout debris deposited on the soil surface tended to become mechanically trapped, the amount redistributed declining with time. Strong winds, however, caused material to be redistributed at concentrations equal to the initial contamination especially in areas having a sparse vegetative cover. The concentration of fallout debris in the surface inch of soil at two stations contaminated by Smoky Shot did not significantly change between D + 3 days and D + 300 days. Particles 44-88 microns in diameter contributed an average of 9.7 percent of the total redistributed fallout following Priscilla as compared to 21.0 percent following Smoky. Particles less than 44 microns in diameter contributed an average of 85.8 percent following Shot Priscilla compared to 68.3 percent following Shot Smoky. Aerosol concentrations were similar following both Shots Priscilla and Smoky despite significant differences in initial contamination. The original fallout contamination of native plant material persisted through the 18 day period following Shots Priscilla and Smoky. (Authors) Keywords: climate*, radionuclide inventory*, vegetation*, radiation*

398 **LEAVITT, V.D. 1970. Soil survey of Area 18, Nevada Test Site. SWRHL-74r, 119 pp. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Las Vegas, NV.**

A soil survey of Area 18, which lies in the northwestern portion of the Nevada Test Site, was undertaken to obtain information on the soil and vegetation being grazed by the USAEC beef herd. Twenty soil series descriptions, including both physical and chemical analyses, were written and included on soil maps of the area. (TPO) *Keywords:* EPA*, soil property*, vegetation*

399 **LEAVITT, V.D. 1974. Soil surveys of five plutonium contaminated areas on the test range complex in Nevada. NERC-LV-539-28, 84 pp.**

Soils in five areas located on the Test Range Complex, Nye County, Nevada are described. All of the areas have at one time been sites of above-ground nuclear safety tests. The areas are contaminated with plutonium and are, therefore, the object of investigations regarding the movement of plutonium in the environment. Most of the surface soils in the five areas have a gravelly texture and are typically classified as gravelly sandy loam. The majority of the surveyed land is either flood-plain or alluvial fan with deep soils having well-developed profiles and platy structure. All of the soils are alkaline ranging in pH from 7.0 to 9.0. The vegetation is classified in two general categories, low and high desert shrub. The low desert shrubs are predominantly creosote-bush *(Larrea divaricata*) and white bursage (*Franseria dumosa*). The high desert shrubs are mostly fourwing saltbush (*Atriplex canescens*), winterfat (*Eurotia lanata*), and bud sagebrush *(Artemisia spinescens*). (Author) *Keywords:* EPA*, soil property*, vegetation*, perennial plants*

400 **LEAVITT, V.D., and B.J. MASON. 1971. Soil survey of Area 15, Nevada Test Site. SWRHL-106r, 46 pp.**

The results of a soil survey of the area around the Environmental Protection Agency Experimental Dairy Farm located in Area 15 of the U.S. Atomic Energy Commission's Nevada Test Site are reported. Four soil series were identified. Descriptions of these series are included along with physical and chemical analyses of representative samples of the soils. (Authors) *Keywords:* EPA*, soil property*

401 **LEDERLE, P.E. 1997. Growth of Desert Tortoises at Yucca Mountain. In: The Desert Tortoise Council Proceedings of 1997-1998 Symposia, pp. 86-87. Desert Tortoise Council, Inc., Wrightwood, CA.**

We compared growth of three groups of tortoises at Yucca Mountain, Nevada, that differed in the size and duration of disturbances to which they were subjected (High-impact, Low-impact, Control). We tested for differences among groups by comparing yearly growth increments and fitted parameters derived from logistic-by-length growth curves developed using interval equations. Controlling for tortoise size using analysis of covariance, yearly growth increments differed among treatment groups, years, and sex. Pooled over years, tortoises in the low-impact treatment group grew an average of 4.4 mm per year, whereas high-impact and control tortoises grew an average of 3.5 and 2.6 mm per year, respectively. Although there were differences in growth of tortoises among treatment groups, the magnitude of differences over time did not change, indicating that the disparities in growth were most likely not due to factors associated with activities at Yucca Mountain. More likely explanations are habitat variability and local microclimatic differences. Pooled across treatment groups, tortoises grew most in 1995 (6.3 mm), least in 1994 (1.3 mm), and an intermediate amount in 1993 (3.2 mm). Yearly differences in average growth reflect the variability in rainfall during the study and the resulting differences in plant productivity. On average, males had larger yearly growth increments than females, yet these differences were less pronounced for smaller individuals. In all years, smaller tortoises generally grew more in absolute length than larger ones, and this difference was greater during years with higher productivity. Males and females tended to grow at the same rate until they began to diverge at approximately 140 mm carapace length. Growth models confirmed results of analyses on yearly growth increments. Overall, males were predicted to reach approximately 277 mm in length and females approximately 258 mm. Control males were predicted to reach asymptotic sizes approximately 3 mm less than males in the high- or low-impact treatment groups. In contrast, control females were predicted to reach asymptotic sizes approximately 15 mm less than females in the other treatment groups. *Keywords:* YMSCO*, desert tortoise*, life history*

402 **LEDERLE, P.E. 1999. Growth of Desert Tortoises at Yucca Mountain, Nevada. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00088 Rev 00. Las Vegas, NV, 13 pp.**

As part of a program to assess the impacts of the U.S. Department of Energy's Yucca Mountain Site Characterization Project, the growth of desert tortoises (*Gopherus agassizii*), a species protected under the Endangered Species Act, was monitored. The objective of this report is to summarize information gathered on the growth of desert tortoises at Yucca Mountain during 1991 through 1995. The growth of tortoises at Yucca Mountain was influenced by growing season precipitation (October through April), which influences the production of plants available to this herbivorous reptile. Compared to long-term averages, 1995 was a wet year and tortoises grew an average of 8.0 mm in length. During the comparatively dry year of 1994 tortoises grew an average of 2.0 mm. Growth of tortoises at Yucca Mountain was also influenced by the size and sex of the tortoise. On average, annual growth of males was greater than that for females of comparable size, and larger tortoises grew less per year than smaller tortoises. Based on results from growth equations, estimated mean maximum size for tortoises at Yucca Mountain was 279 mm for males and 259 mm for females. These size differences are consistent with populations studied elsewhere. The predicted age at sexual maturity for females at Yucca Mountain was approximately 19 years, which is three to five years older than estimates from other populations of desert tortoises in the Mojave and Sonoran deserts. (Author) *Keywords:* YMSCO*, desert tortoise*, life history*

403 **LEDERLE, P.E., J.M. MUELLER, and E.A. HOLT. 1997. Effects of Site Characterization Activities on the Abundance of Ravens (*Corvus corax*) in the Yucca Mountain Area. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00040 Rev 00. Las Vegas, NV, 17 pp.**

Raven abundance was measured from August 1991 through August 1995 along treatment and control routes to evaluate whether site characterization activities resulted in increased raven abundance at Yucca Mountain. Ravens were more abundant at Yucca Mountain than in the control area, and raven abundance in both areas increased over time. However, the magnitude of differences between Yucca Mountain and control surveys did not change over time, indicating that the increase in raven abundance observed during this study was not related to site characterization activities. Increases over time on both Yucca Mountain and control routes are consistent with increases in raven abundance in the Mojave Desert reported by the annual Breeding Bird Survey of the U.S. Fish and Wildlife Service. Evidence from the Desert Tortoise Monitoring Program at Yucca Mountain suggests that ravens are not a significant predator of small tortoises in this locale. Carcasses of small tortoises (less than 110 mm in length) collected during the study showed little evidence of raven predation, and 59 radiomarked hatchlings that were monitored on a regular basis were not preyed upon by ravens. Overall, no direct evidence of raven predation on tortoises was observed during this study. Small tortoises are probably encountered so infrequently by ravens that they are rarely exploited as a food source. This is likely due to the relatively low abundance of both desert tortoises and ravens in the Yucca Mountain area. (Authors) *Keywords:* YMSCO*, perturbations*, desert tortoise*, bird*, ecology/ecosystem*, nutrition/diet*

404 **LEDERLE, P.E., J.M. MUELLER, and E.A. HOLT. 2000. Raptor surveys in southcentral Nevada, 1991-95. Journal of Raptor Research 34(2):133-136.**

We counted raptors using roadside surveys along two routes in southcentral Nevada from 1991-95. During 226 surveys, we observed a total of 232 raptors representing 12 species. Red-tailed Hawks (*Buteo jamaicensis*) were most commonly seen, followed by Golden Eagles (*Aquila chrysaetos*), Turkey vultures (*Cathartes aura*), Northern Harriers (*Circus cyaneus*) and American Kestrels (*Falco sparverius*). The number of raptors observed did not differ between the two routes and was low compared to other surveys done in the western United States. However, few comparable data from the northern Mojave and southern Great Basin deserts are available. (Authors) *Keywords:* YMSCO*, bird*, ecology/ecosystem*

405 **LEDERLE, P.E., K.R. RAUTENSTRAUCH, D.L. RAKESTRAW, and J.M. MUELLER. 1997. The Distribution and Relative Abundance of Desert Tortoises at Yucca Mountain. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00033. Las Vegas, NV, 16 pp.**

The desert tortoise (*Gopherus agassizii*) is the only resident vertebrate species in the Yucca Mountain area that is protected under the Endangered Species Act. Following the listing of the desert tortoise as endangered (subsequently relisted as threatened), the U.S. Department of Energy entered formal consultation with the U.S. Fish and Wildlife Service. One of the terms and conditions resulting from consultation was that the Department of Energy continue the Desert Tortoise Monitoring Program. That program included as one of its goals the development of a better understanding of the ecology of the desert tortoise population at Yucca Mountain, including assessing the distribution and abundance of tortoises in the area. This report summarizes the information available on the distribution and abundance of desert tortoises in the Yucca Mountain area. Numerous transect surveys conducted from 1981-1989 indicated that tortoises were distributed throughout the Yucca Mountain area. These surveys also indicated that the relative abundance of tortoises was low. Tortoise densities were reported to be from about 4 to 20/km^2. In addition, it was determined that the northern boundary of the distribution of desert tortoises was less than 10 km north of that part of Yucca Mountain being intensively studied as part of the Yucca Mountain Site Characterization Project. A pilot study was conducted in 1990 to assess the use of quadrat sampling to monitor the abundance of tortoises at Yucca Mountain. It was concluded that, because of low tortoise abundance, the number of quadrats required to monitor the abundance of tortoises was prohibitively large. Therefore, the abundance of tortoises at Yucca Mountain was not directly measured or monitored as part of the Desert Tortoise Monitoring Program. However, a large number of tortoises were marked for this program during 1989-1995, and information collected while marking these individuals provides additional insight into the distribution and abundance of tortoises at Yucca Mountain. The number of tortoises observed in a 117-km^2 area was tallied and the distribution of these sightings was mapped. Two smaller areas where intensive tortoise research was conducted from 1989-1995 were identified and the number of tortoises within these areas was tallied to determine the minimum population size. The minimum density of tortoises found in these areas was 10 and 12 tortoises/km^2, which is similar to results reported from earlier surveys. These density estimates are similar to most other areas in southern Nevada near Yucca Mountain, yet are lower than many estimates of tortoise density in the Mojave Desert in California, where densities of greater than 75/km^2 have been reported. (Authors) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*

406 **LEDERLE, P.E., K.R. RAUTENSTRAUCH, D.L. RAKESTRAW, K.K. ZANDER, and J.L. BOONE. 1997. Upper Respiratory Tract Disease and Mycoplasmosis in Desert Tortoises From Nevada. Journal of Wildlife Diseases 33(4):759-765.**

A population of desert tortoises (*Gopherus agassizii*) at Yucca Mountain (Nevada, USA) was monitored during four sampling periods using enzyme-linked immunosorbent assays (ELISA) to determine the percentage of individuals that had been exposed to *Mycoplasma agassizii*, a causative agent of upper respiratory tract disease. Respiratory tract disease has been considered a significant factor in the decline of desert tortoise populations in the Mojave Desert (USA). Few differences between sexes in ELISA values or percentages testing positive were noted. From 15 to 23% of samples per period tested positive for exposure to the mycoplasma. However, we noted few clinical signs of upper respiratory tract disease. This is in contrast to an earlier study which reported a similar proportion of seropositive tortoises as well as a high percentage of tortoises with clinical signs. However, our results are consistent with that study's conclusion that seropositivity for *M. agassizii* was a poor predictor of the likelihood to exhibit clinical signs of upper respiratory tract disease. Earlier reported epizootics of mycoplasma-associated respiratory disease occurred mainly during times of drought. Our samples were collected during a period of average to above-average rainfall, suggesting that manifestation of clinical signs of the disease may depend upon the physiological condition of tortoises which, in turn, is related to environmental conditions. (Authors) *Keywords:* YMSCO*, microbiota*, desert tortoise*, ecology/ecosystem*, physiology*

407 **LEDERLE, P.E., K.R. RAUTENSTRAUCH, D.L. RAKESTRAW, K.K. ZANDER, and J.L. BOONE. 1998. Upper Respiratory Tract Disease in Desert Tortoises at Yucca Mountain. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00051 Rev 00. Las Vegas, NV, 20 pp.**

In response to the Nuclear Waste Policy Act of 1982 and the Nuclear Waste Policy Amendments Act of 1987, the U.S. Department of Energy (DOE) developed and is implementing the Yucca Mountain Site Characterization Project. Desert tortoises at Yucca Mountain were studied to evaluate the effects of site characterization activities on the prevalence of upper respiratory tract disease and to develop a better understanding of the effects of that disease on the tortoise population at Yucca Mountain. This study fulfills the requirement set forth in the incidental take provisions of the Biological Opinion that DOE monitor the presence of disease in the desert tortoise population at Yucca Mountain. Blood samples were collected from radiomarked tortoises four times from September 1993 through September 1995 to test for antibodies specific to *Mycoplasma agassizii*, a bacterium that causes upper respiratory tract disease. In addition, tortoises were examined for clinical signs of the disease each time they were handled. To evaluate the effects of site characterization activities, antibody levels from two groups of tortoises living near disturbances at Yucca Mountain were compared to a group of tortoises living in an undisturbed area. The Yucca Mountain Site Characterization Project had no detectable effect on the disease status of tortoises during this study. Overall, 18.7% of 283 blood samples tested positive for antibodies. The percentage of tortoises testing positive for antibodies did not change during the study, but the average antibody levels of 31 tortoises sampled during all periods did increase over time. This increase was similar in tortoises at Yucca Mountain and in the nearby undisturbed area, indicating that site characterization activities did not influence antibody levels in the population. Very few tortoises had clinical signs of upper respiratory tract disease. Signs were observed during only 6 of 1,294 times tortoises were examined in the field. Clinical signs also were observed during 6 of 283 examinations performed in the laboratory prior to drawing blood. In all cases, the clinical signs observed were minimal; tortoises had a slight discharge from their eyes or nasal openings, but otherwise appeared healthy. Of the six tortoises that showed clinical signs prior to drawing blood, only one tested positive for antibodies. Exposure to *Mycoplasma agassizii* had little or no detectable effects on the reproduction or survival of tortoises at Yucca Mountain. There was no difference in egg production during 1994 and 1995 between females that tested positive for antibodies versus those that tested negative during September of those years. During 1994, there was a slight difference in egg production between females that tested positive versus those that tested negative during June of that year. However, samples sizes were too small to make this test conclusive. Survival of all tortoises tested was very high during this study (greater than 99%). It was concluded that the Yucca Mountain Site Characterization Project did not result in any detectable increases in the presence of antibodies specific to *Mycoplasma agassizii* during 1993-1995. Although tortoises at Yucca Mountain had been exposed to a causative agent of upper respiratory tract disease, lack of clinical signs, inconclusive impacts on egg production, and high survival rates indicate that upper respiratory tract disease was not negatively affecting the tortoise population at Yucca Mountain during this study. (Authors) *Keywords:* YMSCO*, microbiota*, desert tortoise*, ecology/ecosystem*, life history*

408 **LINDBERG, R.G. 1959. Factors influencing the biological consequences of environmental contamination by nuclear debris. In: Proceedings of the Second Plowshare Symposium, San Francisco, CA, May 1959. Part II. Excavation (USAEC Report UCRL-5676), pp. 42-59.**

The physical and chemical properties of fall-out debris are discussed. It is pointed out that the biological consequences of environmental contamination by radioactive debris are largely a function of the physical characteristics of the contaminants and the utilization of the contaminants by plants or animals is dependent upon the material being in a soluble or digestible form. Until this occurs the effect of radioactive debris is limited to the production of an external radiation field of rapidly declining intensity. A review of data on fall-out from previous detonations suggests that whatever the conditions of surface or above-ground detonation may be, a complete spectrum of kinds of fallout particles are produced but with the proportion of those bearing a specific set of characteristics dependent upon the nature of the detonation. The conditions of detonation, therefore, strongly influence the physical properties of the particles produced. The biological effects of fall-out are largely dependent upon particle size, physical and chemical properties, and the specific radioisotopes that are present. It is anticipated that in the case of excavation detonations neutron-induced activity may make the most significant contribution to the fall-out field during the acute periods of contamination if significant amounts of radioactive debris should escape during excavation events. The biological problems resulting are probably of a short-term nature. Data are tabulated on isotopic fractionation and fall-out pattern during Operation Plumbbob. In its general characteristics, it is representative of fall-out patterns produced by shallow underground, tower-, or balloon-supported detonations. If venting should occur during excavation activities of the Plowshare Program, it would be expected that escaping radioactive debris would be deposited in a similar pattern. The radiation intensity will depend upon the energy yield, the specific design of the device, the location of the device with regard to the ground surface, and meteorological conditions. Ecological concepts which must be considered in evaluating the biological consequences of radioactive contamination are discussed. (CH) *Keywords:* EPA*, radionuclide inventory*, vegetation*, vertebrate*, radiation*

409 LINDBERG, R.G., and K.H. LARSON. 1956. The short term biological fate and persistence of radioactive fallout as measured at various locations within fallout patterns. In: (Dunning, G.M., and J.A. Hilcken, Eds.) Proceedings of the Symposium on the Shorter-Term Biological Hazards of a Fallout Field, Washington, D.C., December 1956, pp. 197-204.

Data was collected during weapons testing programs and up to one year following fallout contamination of an environment. The particular components studied were air, soil, plants, native rodents, and fallout, and the kinds of environment varied from the semiarid desert valleys to juniper and pinon covered slopes to relatively rich agricultural areas. The kangaroo rat, genus Dipodomys, and the jackrabbit, genus Lepus were used as indicators of the biological availability of radioactive fallout to other mammals. The persistence of fission products in various tissues from a natural population of kangaroo rats over a period of 90 days following a single fallout contamination in the spring of 1953 is presented graphically, as is the buildup of radioiodine in the thyroid of kangaroo rats and jack rabbits sampled from a fallout area located 12 miles from Ground Zero (GZ) during the spring of 1955. The occurrence of radiostrontium in the bones of jackrabbits from the midline of residual fallout contamination was compared to distance of the sampling site from the Nevada Test Site and to the degree of residual environmental contamination. The 90Sr activity in the bones along the midline of residual fallout increased out to 130 miles and then decreased slightly and leveled off. During the weapons testing program the predominant size of fallout particles greater than 100 µ in diameter decreased with distance from GZ while the less than 100 µ material did not decrease but remained the same or increased with distance up to 200 miles from GZ. The majority of particles retained by foliage was below 44 µ in diameter having an average size of approximately 20 µ. The smaller size material tended to be more soluble and therefore potentially more available to the biological cycle. (FMM) *Keywords:* radionuclide inventory*, vegetation*, mammal*, radiation*

410 LINDBERG, R.G., E.M. ROMNEY, J.H. OLAFSON, and K.H. LARSON. 1959. Factors influencing the biological fate and persistence of radioactive fall-out (Operation Teapot). WT-1177, 78 pp.

During Operation Teapot the biological accumulation of fission products derived from nuclear detonations was studied as functions of the distance of the sampling site from Ground Zero (GZ), radioactive particle size distribution, and fractionation of fallout material as it may vary with distance from GZ. This included studies on the persistence of fission products in plants and animals living in contaminated environments, the availability of fallout material to plants under various conditions of contamination, evaluation of inhalation as a significant phenomenon in the uptake of fission products in actual fallout areas, and the determination of the percentage distribution of the total body burden of certain isotopes in the tissues of animals exposed to fallout. Preliminary data indicate that the activity measured in plant samples collected from fallout areas is the result of external contamination by radioactive fallout particles less than 44 microns in diameter. The degree of plant contamination is a function of the mechanical distribution of the less than 44 micron size particles within a distance of 100 miles from GZ, which is in turn influenced by such conditions of weapon detonation as tower height and meteorology. The radioactive fallout material on plant foliage is persistent as evidenced by the activity remaining on leaves even after washing in Versene and 0.1 N HCl solutions, or by the mechanical shaking brought about by severe wind storms. The tissue burdens of fission products in animals sampled from fallout contaminated environments tend to decrease with distance from GZ similarly to the degree of plant contamination. The activity per unit weight of femur, however, tends to remain fairly constant to a distance of 140 miles from GZ. The thyroid shows a greater tissue burden of radioiodine at 60 miles than at 12 miles from GZ. The tissue burden then declines similarly to other tissues. The relative decrease in tissue burdens of fission products in native animals serially sampled from the same fallout contaminated environment in most cases did not markedly deviate from the radioactive decay rate of mixed fission products (t (E-1.2)). The activity per unit weight of femur, however, gradually increased until 3 days post-shot and then decreased. The thyroid activity continued to rise throughout the 15 day sampling period. Iodine 133 is believed to contribute largely to the thyroid burden during the first 3 days following the detonation. The close correlation in most cases between the relative tissue activity and the activity of the digestive tract contents suggests that ingestion is the principal source of tissue activity. The data indicate that a rapid equilibrium between the absorbed activity and that passing through the gut may have been established within the first 2 days following fallout. Data suggest that inhalation is a negligible path of uptake of fission products during and after fallout contamination. (Authors) (FMM) *Keywords:* radionuclide inventory*, vegetation*, vertebrate*, radiation*

411 LINDBERG, R.G., J.T. SCANLAN, J.C. WATSON, W.A. RHOADS, and K.H. LARSON. 1954. Environmental and biological fate of fallout from nuclear detonations in areas adjacent to the Nevada Proving Grounds (Operation

Upshot-Knothole). WT-812, 54 pp.

A radio-ecological survey of the area adjacent to the Nevada Proving Grounds in progress intermittently from Sept. 1951 to July 1953 is summarized. Samples have been taken periodically of soils, plants, and animals before, during, and after various test series at distances up to 30 miles from ground zero. Conclusions are drawn on the fission product burden in animal tissue. (WDM) *Keywords:* radionuclide inventory*, vegetation*, vertebrate*, radiation*

412 **LUCAS, A.C., and N.R. FRENCH. 1967. A miniature thermoluminescent dosimeter and its application in radioecology. In: (Attix, F.H., Ed.) *Luminescence Dosimetry*, AEC Symposium Series 8, pp. 402-411.**

Glass capillary dosimeters containing CaF_2:Mn or LiF were constructed to measure radiation exposures of free-ranging small animals. In the 1 to 1000 R range they had a precision of ±0.1 R or ± 3%, whichever was greater. Reading of exposures was facilitated by an externally heated coil of Nichrome wire. (TPO) *Keywords:* vertebrate*, radiation*, methods*

413 **LUO, Y., and J.F. REYNOLDS. 1999. Validity of extrapolating field CO_2 experiments to predict carbon sequestration in natural ecosystems. Ecology 80:1568-1583.**

One of the ultimate goals of ecosystem carbon dioxide (CO_2) experiments is to infer the capacity of terrestrial ecosystems to sequester carbon (C) in a CO_2-enriched world. This modeling study examines C sequestration (C_{seq}) in natural ecosystems based on CO_2 experiments. Most experiments are conducted by a step increase in CO_2 concentration, whereas natural ecosystems are experiencing a gradual increase in atmospheric CO_2 (C_a). To examine the effects of a step vs. gradual CO_2 increase on ecosystem responses, we have developed a terrestrial C sequestration (TCS) model that focuses on C and nitrogen (N) interactions in regulating C_{seq}. We used the model to: (1) compare C_{seq} and N demand in response to the step vs. gradual increase in CO_2; (2) identify mechanisms underlying different ecosystem responses to the step vs. gradual CO_2 forcing; (3) examine key parameters in controlling C_{seq}; and (4) explore three hypothesized N supply mechanisms in regulating photosynthetic acclimation and C_{seq}. Application of this model to simulate responses of a forest ecosystem with gross primary productivity of 1200 g $C \cdot m^{-2} \cdot yr^{-1}$ suggested that a step increase in CO_2 from 350 to 700 ppm resulted in C_{seq} of 263 g $C \cdot m^{-2} \cdot yr^{-1}$ in the first year. A gradual C_a increase led to the C_{seq} rates of 27 and 58 g $C \cdot m^{-2} \cdot yr^{-1}$ in 1987 and 2085 when CO_2 reached 350 and 700 ppm, respectively. The model predicted that N demand required to balance the additional C influx was 4.1 g $N \cdot m^{-2} \cdot yr^{-1}$ in the step CO_2 increase and only 0.6 and 1.7 g $N \cdot m^{-2} \cdot yr^{-1}$ in 1987 and 2085, respectively, in the gradual C_a increase. The contrasting differences in C_{seq} and N demand between the two increase scenarios reflected the nature of C fluxes that were controlled by the sizes of donor pools (i.e., donor-controlled system). Our modeling analysis of four ecosystems (forest with high productivity [HP]; grassland with HP; forest with low productivity [LP]; and grassland with LP) indicated that additional C influx and C relaxation time are the key parameters in determining ecosystem C_{seq}. The additional C influx varied with ecosystem productivity and N regulation, while C relaxation time differed between the forests and grasslands due to woody tissues and litter in the forests. We conclude that in spite of the fact that the step experiment is one of the most effective approaches in ecosystem studies, its results cannot be directly extrapolated to predict terrestrial C_{seq} in natural ecosystems responding to a gradual C_a increase. In order to develop predictive understanding from the step experiments, we need not only to improve experimental design and measurement plans, but also to develop new approaches, such as deconvolution and inverse modeling, for data analysis and interpretation. (Authors) *Keywords:* FACE*, perturbations*, vegetation*, physiology*, methods*

414 **LYNN, R.L., D.G. CRANDALL, R.K. MULLEN, and W.A. RHOADS. 1970. Gamma radiation spectra in the vicinities of Projects Shoal and Faultless. USAEC Report EGG-1183-2255, 15 pp.**

The scintillator array used in the Aerial Radiological Measurement Survey (ARMS) System was employed in ground-based gamma radiation surveys of the Project Shoal and Project Faultless sites. Measurements were made at nine locations at the Project Shoal site and at four locations at the Project Faultless site. On the basis of an unconfirmed report of possible low-level radioactive contamination at the Project Shoal site, six rodents were trapped and removed from that site for whole-body gamma spectral analysis. Computerized analysis of the gamma spectra obtained at the Project Shoal site revealed a radiation peak in the 0.650-0.670 MeV region at some, but not all, of the locations where measurements were made. The origin of this radiation, which has tentatively been identified as Cs-137, is unknown. Similar analysis of the gamma spectra obtained at the Project Faultless site revealed no radiation peaks not attributable to normal background. Whole-body counts made on the rodents secured from the Project Shoal site revealed no radiation burden other than normally occurring K-40. The lack of any discernable peak in the 0.650-0.670 meV region would suggest that the radioactive contaminant present at the Project Shoal site is not involved in the food-chain kinetics of the resident rodent population.

(Authors) *Keywords:* radionuclide inventory*, mammal*, radiation*, methods*

415 **MANKAU, R. 1979. Biology of nematodes in desert ecosystems. US/IBP Desert Biome Res. Memo. 77-18. Utah State University, Logan, 11 pp.**

Nematode populations from soil taken in a standardized random sampling pattern around roots of dominant plants in five desert sites in California, Nevada, Arizona, Utah and New Mexico were compared and studied in relation to biomass, spatial distribution and trophic groups. The sampling program included three depths (10, 20 and 30 cm) at the plant bases, at the edge of the plant canopy and at three times the mean radius of the shrub canopy where applicable. Horizontal positioning of depth samples was altered for dominant grasses and, when dictated, by plant spacing. Nematodes were recovered by a modified sugar flotation method and counted, and the data were corrected to nematodes/1,000 g soil. They were identified as microbivores, fungivores, predator/omnivores and plant-parasites/miscellaneous Tylenchida. They were then fixed and stored for taxonomic study. An examination of the effects of four levels of simulated rainfall applied in two different time sequences was made at the Rock Valley, Nevada site. Greatest numbers of all nematode groups occurred in the top 10 cm of soil near the plant bases and generally decreased significantly with depth and horizontal distance from the plants, but the rate of decrease varied between different deserts and appeared to be related to average annual rainfall and general plant biomass. Microbivores at all locations were composed almost entirely of Cephalobidae. Percentages of different trophic groups in populations varied considerably between sites as did species composition of groups. Added moisture had only very short-term effects on the population tested. (Author) *Keywords:* IBP*, invertebrate*, ecology/ecosystem*

416 **MARTIN, F.M., R.A. FAUST, and C.T. SANDERS (Eds). 1975. Environmental Aspects of the Transuranics - A Selected, Annotated Bibliography. NVO-AEIC-75-2, Nevada Applied Ecology Group Nevada Operations Office, Oak Ridge National Laboratory, 200 pp.**

This sixth published bibliography of 470 references is from the computer file built to provide information support to the Nevada Applied Ecology Group (NAEG) of ERDA's Nevada Operations Office. The general scope is environmental aspects of uranium and the transuranic elements, with emphasis on plutonium. Biological aspects of the transuranics is highlighted in this bibliography. In addition, supporting materials involving basic ecology studies, ecology of the Nevada Test Site and reviews on other radionuclides are entered at the request of the NAEG. Significant numeric data is shown in tabular display or is noted for reference to the original document. The references are arranged by subject category with first authors arranged alphabetically within the category. Indexes are given for author, keywords, geographic location, permuted title, taxons, and publication description. (Authors) *Keywords:* NAEG*, bibliography*, vegetation*, invertebrate*, vertebrate*, ecology/ecosystem*, radiation*

417 **MARTIN, F.M., C.T. SANDERS, and S.S. TALMAGE (Eds). 1974. Environmental Aspects of the Transuranics - A Selected, Annotated Bibliography. ORNL-EIS-74-21, Nevada Applied Ecology Group Nevada Operations Office, Oak Ridge National Laboratory, 226 pp.**

This fourth published bibliography of 528 references is from the computer information file built to provide support to the Nevada Applied Ecology Group (NAEG) of the AEC Nevada Operations Office. The general scope is environmental aspects of uranium and the transuranic elements, with a preponderance of material on plutonium. In addition, there are supporting materials involving basic ecology or general reviews on other nuclides that are entered at the request of the NAEG. References provide findings-oriented abstracts. Numerical data is referred to in the comment field. Indexes are given for author, subject category, keywords, geographic location, permuted title, taxons, and publication description. (Authors) *Keywords:* NAEG*, bibliography*, vegetation*, invertebrate*, vertebrate*, ecology/ecosystem*, radiation*

418 **MARTIN, J.R., and J.J. KORANDA. 1971. Distribution, residence time, and inventory of tritium in Sedan crater ejecta. Nuclear Technology 11:459465.**

Radioecological studies were conducted over a five-year period to characterize the distribution and residence time of tritium in soil samples from ejecta of the Sedan crater. Extracted water was assayed by liquid scintillation counting. Kangaroo rats were trapped and monthly body-water tritium concentrations were plotted as a function of time. Residence half-time for tritium in the rats was determined to be 14.5 plus or minus 1.4 months. The agreement of tritium residence time in the body water of the rat with that obtained from the soil data suggests that the surface-to-six-foot interval is the biologically significant zone for tritium in the desert ecosystem at Sedan crater. The tritium inventory in the ejecta at T sub 0 is reported as (1.5 plus or minus 0.2) x 10(E+6) uCi. (BBM) *Keywords:* radionuclide inventory*, mammal*, radiation*

419 **MARTIN, J.R., and J.J. KORANDA. 1972. Biological half-life studies of tritium in chronically exposed kangaroo rats. Radiation Research 50:426440.**

The biological half-life of tritium was measured in the body water and in brain, liver, lung, kidney, heart and muscle tissues of two groups of kangaroo rats captured in the tritiated environment at Sedan crater in the Nevada Test Site. These animals had been exposed to tritium in their natural food for their entire lifetime. The rodents were maintained on tritium-free food in the laboratory during the two study periods of five and nine months. At regular intervals, several animals from each group were killed, dissected and lyophilized. Tritium in the body water was determined by liquid scintillation counting. Dried tissue residues were assayed by sealed-flask combustion and liquid scintillation counting. The biological half-life of tritium in the tissue compartment of these uniquely exposed animals was 1.5 to 4 times that of the body water. At the time of trapping, a slight enrichment of tritium in tissue was indicated by the initial ratio of tissue to body water tritium which ranged from 1.2 to 1.6 with an average value of 1.40 ± 0.14. (Authors) *Keywords:* mammal*, radiation*

420 **MARTIN, W.E. 1962. Applications of fundamental biology to the needs of man. 4. Radioecology and the study of environmental radiation. USAEC Report TID-16060, 71 pp.**

A review is given of some of the ecological aspects of the problems of the atomic age which deal with the collection of data and the development of concepts to be used in making realistic, quantitative evaluations of the biological hazards, if any, resulting from increased environmental radiation due to fallout. The major topics considered are: the kinds and amounts of natural and man-made sources of ionizing radiation in the biosphere; the formation and dispersal of fallout, including a comparison of local, tropospheric and stratospheric fall-out patterns; the redistribution of fall-out materials by environmental processes, their, accumulation by plants and animals, and their cycling in terrestrial foodchains; and the evaluation of potential biological hazards arising from small increases in external and internal exposure of organisms to ionizing radiation. (Author) *Keywords:* radionuclide inventory*, vegetation*, vertebrate*, radiation*

421 **MARTIN, W.E. 1963. Close-in effects of an underground nuclear detonation on vegetation. I. Immediate effects of cratering, throw-out, and blast (Project Sedan). USAEC Report PNE-228P, 41 pp.**

Operation Sedan involved the detonation of a nuclear device at a depth of almost 650 ft in the alluvium of Yucca Flat, Nevada. Preliminary results are reported for studies dealing with the immediate close-in effects of this detonation on vegetation. (Author) *Keywords:* perturbations*, vegetation*, radiation*

422 **MARTIN, W.E. 1963. Loss of I^{131} from fallout-contaminated vegetation. Health Physics 9:1141-1148.**

While the radioactive half-life of I^{131} is 8.04 days, its effective half life on fallout-contaminated vegetation was found to be only 5.5 days. Experimental evidence indicated that the difference may have been due to the mechanical removal of particles from vegetation and/or to the vaporization of I^{131} from particles retained by vegetation. These findings imply that I^{131} and other radionuclides contained in fallout may be lost from the diets of herbivores at rates significantly greater than could be predicted on the basis of radioactive decay alone. (Author) *Keywords:* vegetation*, mammal*, nutrition/diet*, radiation*

423 **MARTIN, W.E. 1963. Notes on the deposition of fallout in relation to topography and local meteorological conditions. USAEC Report UCLA-513, 17 pp.**

Activities in a program to collect radioactive effluents released during the test operation of a Kiwi reactor (Kiwi B-la) on December 7, 1961, are reported. Granular fallout collectors and cheesecloth aerosol collectors were prelocated along roads approximating arcs of 5, 16, and 37 miles from the reactor test cell at the Nevada Test Site. Each of these arcs crossed successively lower and wider parts of a gently sloping valley. A last-minute shift in wind direction carried the effluent cloud away from the prelocated sampling devices. Apparently, the cloud was trapped until nightfall in an inversion layer from 2,000 to 3,500 feet above the surface. During the night following the reactor test, tropospheric or stratospheric fallout probably derived from nuclear detonations in the U.S.S.R. (but no short-lived fission products) were deposited on the abovementioned sampling devices. The shallow-valley inversion and cold air drainage caused the pattern of this deposition to be closely related to the local topography. The beta-gamma activity deposited on samplers at low elevation (presumably below the valley inversion layer) was less than that deposited on samplers at higher elevations. The highest levels of beta-gamma activity were detected on samplers which had been located directly in the most probable pathway of nocturnal cold-air drainage. Further studies are recommended. (Author) *Keywords:* climate*, radionuclide inventory*

424 MARTIN, W.E. 1964. Losses of Sr^{90}, Sr^{89}, and I^{131} from fallout-contaminated plants. Radiation Botany 4:275-284.

During the early period following local fallout, and during periods of maximal worldwide fallout, the entry of radionuclides into terrestrial food chains is due primarily to the external contamination of plants and secondarily to the uptake of radionuclides from contaminated soil. The following studies were undertaken to estimate the rates of radionuclide loss from fallout-contaminated vegetation and hence from the diets of herbivores, living in a fallout field. On the fifth, fifteenth, thirtieth, and sixtieth days after an underground nuclear explosion (Operation Sedan) at the Nevada Test Site, plant samples were collected from twenty representative locations in the fallout field and analyzed to determine the concentrations (pc/g dry wt) of ^{90}Sr, ^{89}Sr, and ^{131}I at the times of collection. While the radioactive half-lives of ^{90}Sr, ^{89}Sr, and ^{131}I are approximately 27.7 years, 53 days, and 8.04 days respectively, their average effective half-lives on fallout contaminated plants, during the period from 5 to 30 days after the detonation, were 27.8 days, 17.8 days and 5.0 days respectively. Losses of ^{90}Sr and ^{89}Sr were attributed to radioactive decay and to the removal of fallout particles and foliage by wind and/or other mechanical disturbances. Losses of ^{131}I were attributed to radioactive decay, to mechanical disturbance, and to the vaporization of ^{131}I from the fallout particles retained on foliage. (Author) *Keywords:* vegetation*, radiation*

425 MARTIN, W.E. 1964. Radioecology and the study of environmental radiation. Bull. Torrey Bot. Club 91:283-323.

A review is given of some of the ecological aspects of the problems of the atomic age which deal with the collection of data and the development of concepts to be used in making realistic, quantitative evaluations of the biological hazards, if any, resulting from increased environmental radiation due to fall-out. The major topics considered are: the kinds and amounts of natural and man-made sources of ionizing radiation in the biosphere; the formation and dispersal of fall-out, including a comparison of local, tropospheric and stratospheric fall-out patterns; the redistribution of fall-out materials by environmental processes, the accumulation by plants and animals, and their cycling in terrestrial food chains; and the evaluation of potential biological hazards arising from small increases in external and internal exposure of organisms to ionizing radiation. (Author) *Keywords:* radionuclide inventory*, vegetation*, vertebrate*, nutrition/diet*, radiation*

426 MARTIN, W.E. 1965. Early food-chain kinetics of radionuclides following close-in fallout from a single nuclear detonation. In: (Klement, A.W., Jr., Ed.) *Radioactive Fallout from Nuclear Weapons Tests*, AEC Symposium Series 5 (CONF-765), pp. 758-782.

Plant samples and rabbits were collected from representative locations in the Sedan fallout field before and at various times after the detonation. Radiochemical and statistical analyses indicated highly significant correlations between estimates of gamma dose rates and maximum concentrations of Sr-89 or I-131 in plant samples and in the stomach contents, bone ash, or thyroids of rabbits collected between 15 and 100 miles from ground zero. The effective half-lives of Sr-89 and I-131 on fallout-contaminated plants were approximately 18 and 5.0 to 5.5 days, respectively. Maximum concentrations of Sr-89 in rabbit bone ash occurred about 30 days after the detonation and remained high for at least 60 days; but maximum concentrations of I-131 in rabbit thyroids occurred by or before five days and then declined to pre-Sedan levels in less than 60 days after the detonation. Deterministic exponential models were formulated and found to function satisfactorily, with parameter values derived from the data, in providing a partial explanation of the quantitative kinetic relations between initial concentrations of Sr-89 and I-131 on plants and subsequent concentrations in the bone ash or thyroids of rabbits collected in the Sedan fallout field. Major sources of error in the estimation of input-parameter values and in the use of such models to make predictions are described and discussed. Similar models were proposed for the study of radionuclide kinetics in human food chains (i.e., pasture plants, cow milk, and human tissues or organs) following environmental contamination by a single fallout event. The results of hypothetical

calculations were compared with radiation protection guides recommended by the Federal Radiation Council. (Author) *Keywords:* vegetation*, mammal*, nutrition/diet*, radiation*, methods*

427 MARTIN, W.E. 1965. Interception and retention of fallout by desert shrubs. In: (Hungate, F.P., Ed.) *Radiation and Terrestrial Ecosystems*, Health Physics 11:1341-1354.

Concentrations of I-131 and Sr-89 on plants contaminated by fallout from Project Sedan tended to decrease with increasing distance from ground zero and increasing time after the detonation. Microscopic and radiometric examinations of foliage indicated that most of the activity deposited on leaves was probably due to particles <5 a in diameter, and virtually none of it was due to particles >44 a in diameter. A comparison between the theoretical and observed interrelations of gamma dose rates, I-131 and Sr89 deposition rates, and I-131 and Sr-89 interception by desert shrubs indicated a deficiency of I-131 relative to Sr-89 in areas more than 40 miles from ground zero and an excess of both I-131 and Sr-89 relative to dose rates in areas about 100 miles from ground zero. The effective halflives of I-131 and Sr-89 on plants were shorter than their radioactive halflives and a comparison of environmental half-lives suggested that I-131 may have been lost from plants by some process, such as vaporization, which had no effect on the retention of Sr-89. Statistical analyses indicated that the frequency distributions of variates representing maximum concentrations of I-131 and Sr-89 on plants, and in the tissues of rabbits collected at the same times and locations in the fallout field, were not normal but lognormal. Similar analyses indicated that the frequency distributions of effective half-life estimates could be treated as either normal or lognormal. (Author) *Keywords:* perennial plants*, mammal*, radiation*

428 MARTIN, W.E. 1966. Close-in effects of nuclear excavation and radiation on desert vegetation. In: (Sacher, G.A., Ed.) *Radiation Effects on Natural Populations*, pp. 7-9.

Detonation of the Sedan device subjected native vegetation to high levels of radiation and dust. The plants exhibited various degrees of damage, but these effects may have been due to exposure to dust alone rather than radioactivity. (TPO) *Keywords:* perturbations*, vegetation*, radiation*

429 MARTIN, W.E., and F.B. TURNER. 1963. Increased environmental radiation in southern Nevada, October-December 1961. USAEC Report UCLA-518, 45 pp.

Soils, plants, and animals were collected in October and early November 1961 from areas at and near the Nevada Test Site. Similar samples were collected after the Kiwi B-la reactor test of December 7, 1961. Radiochemical and statistical analyses provided evidence for the following conclusions: (1) the gross beta activity of soils in southern Nevada tended to decrease with increasing distance from the Nevada Test Site and appeared to be related to the general pattern of fallout from nuclear detonations during the 1950's, (2) the gross beta activity of plant samples also tended to decrease with increasing distance from the Nevada Test Site, but the differences between geographically comparable areas were not statistically significant, (3) there was, during late November and early December, a significant and geographically uniform increase in the beta activity of plants and rabbit stomach contents both at and to the south of the Nevada Test Site, (4) similarly, there were increases in the radiostrontium content of rabbit bones and in the Cs-137 content of rabbit muscle, (5) most of the observed increase of environmental radiation in southern Nevada was due to radioisotopes such as Sr-89, Y-91, Ce-141, and Ce-144 having intermediate half-lives, (6) evidence of marked increases in plant and animal contamination by shortlived radioisotopes such as I-131, I-133 and by Sr-91:Y-91 was restricted to areas in the immediate, downwind vicinity of the reactor test cell, (7) the major increase of environmental radiation, in southern Nevada during November 1961, was due to fallout from nuclear detonations in the U.S.S.R., and (8) increases of environmental radiation attributable to the deposition of radioactive effluents from the Kiwi reactor were minor and highly localized. (Authors) *Keywords:* radionuclide inventory*, vegetation*, mammal*, radiation*

430 MARTIN, W.E., and F.B. TURNER. 1965. Food-chain relationships of radiostrontium in the Sedan fallout field. USAEC Report PNE-237F, 61 pp.

Plant samples and rabbits were collected before and at various times up to 33 days after the detonation from 20 representative locations in the Sedan fallout field. Radiochemical analyses were made to determine the concentrations of Sr-89 and Sr-90 in dry plant samples and in the bone ash of rabbits at the times of collection. Estimates of initial gamma dose rates (R_0= mr/hr, 3 ft aboveground, 24 hr after the detonation) were obtained from aerial survey data. The average concentrations, build-up, and later decline of radiostrontium in the bone ash of rabbits collected in the Sedan fallout field were apparently due to the initial concentrations of radiostrontium on the fallout-contaminated plants consumed by the rabbits; the weight of contaminated plant material consumed per rabbit per day; the weight of bone ash per rabbit; the fraction of ingested radiostrontium which was assimilated and deposited in bone; the effective half-life of radiostrontium on fallout-contaminated plants; and the effective half-life of radiostrontium in the skeleton. A mathematical model incorporating these parameters was formulated and found to function satisfactorily with parameter values derived from the radiochemical data. Estimates of the total doses (rad) delivered by Sr-89 to rabbit bone were based on the model. The estimated doses to individual rabbits ranged from 0.11 to 9.48 rad, and the average was 1.12 ± 0.36 rad. While the model seems to provide an adequate explanation of the quantitative-kinetic relationship between average initial concentrations of radiostrontium on plants and subsequent average concentrations in rabbit bone ash, the parameter values used in fitting the hypothetical curves to the observed data points could be inaccurate; and even if the derived parameter values are accurate, they might not be applicable to other fallout fields. Some of the factors which influence the parameters considered in the model, and the major sources of error in estimating specific parameter values were discussed at length. A mathematical model was proposed to provide at least a partial explanation of the quantitative-kinetics of Sr-89 or I-131 on pasture plants, in cow's milk, and in human tissues (bone and thyroid) following fallout from a single nuclear detonation. The potential value of the proposed model as an aid in the study of human food-chain kinetics or for the interpretation of radiochemical data was illustrated by means of hypothetical calculations. (Authors) *Keywords:* vegetation*, mammal*, nutrition/diet*, radiation*, methods*

431 **MARTIN, W.E., and F.B. TURNER. 1966. Transfer of ^{89}Sr from plants to rabbits in a fallout field. Health Physics 12:621-631.**

A study was conducted in the fallout field produced on July 6, 1962 by Project Sedan to formulate a mathematical model to represent the relationship between gamma dose rates and initial Sr-89 concentrations on fallout-contaminated plants and the time-specific relationship between Sr-89 concentrations on plants and in the bone ash of rabbits collected at the same times and locations in the fallout field. Estimates of gamma dose rates 24 hr after the detonation were based on the results of aerial radiometric surveys. Estimates of the time-specific concentrations of Sr-89 on plants and in rabbit bone ash were based on analyses of samples collected before and 5, 15, 30, and 60 days after the detonation at twenty representative locations in the Sedan fallout field. Correlation and regression coefficients based on estimated gamma dose rates and observed Sr-89 concentrations in plant and bone ash samples were highly significant, and analyses of variance indicated no significant deviations from linear regression. The average initial concentrations of Sr-89 on desert shrubs in the Sedan fallout field were approximately 103 pc/g per mR/hr. The average concentrations of Sr-89 in plant samples collected 5, 15, 30, and 60 days after the detonation were 1436, 909, 544, and 313 pc/g respectively. The average concentrations of Sr-89 in rabbit bone ash samples collected 5, 15, 30, and 60 days after the detonation were 863, 1680, 2097, and 1389 pc/g respectively. Estimates based on the 18-day effective half-life of Sr-89 on plants indicated an effective half-life of about 20 days for Sr-89 in rabbit skeletons. Estimates suggested that only 5.75 percent of the Sr-89 ingested was assimilated and deposited in rabbit bone. An exponential model based on the parameters described above was tested and found to provide a reasonable representation of the time-specific relationship between Sr-89 concentrations on fallout-contaminated plants and in rabbit bone ash. Using the same model to estimate the infinity doses delivered by Sr-89 to rabbit bone, indicated a range from about 0.1 to 9.5 rad and an average of 1.12 ± 0.36 rad in areas 12 to 110 miles from ground zero. Estimates of integrated doses indicated that 93 percent of the infinity dose was delivered during the first 120 days after the detonation. (Authors) *Keywords:* vegetation*, mammal*, nutrition/diet*, radiation*, methods*

432 **MARTIN, W.E., G.E. RAINES, S.G. BLOOM, and A.A. LEVIN. (Unknown date). Ecological transfer mechanisms - terrestrial. In: Proceedings of the Symposium on Public Health Aspects of Peaceful-Uses of Nuclear Explosives held at Las Vegas, NV, April 1969 (SWRHL-82), pp. 401-435.**

Radionuclides produced by nuclear excavation detonations and released to the environment may enter a variety of biogeochemical cycles and follow essentially the same transfer pathways as their stable-element counterparts. Estimation of potential internal radiation doses to individuals and/or populations living in or near fallout-contaminated areas requires analysis of the food-chain and other ecological pathways by which radionuclides released to the environment may be returned to man. A generalized materials transfer diagram, applicable to the forest, agricultural, and freshwater and marine ecosystems providing food and water to the indigenous populations of Panama and Colombia in regions that could be affected by nuclear excavation of a sea-level canal between the Atlantic and Pacific Oceans, is presented. Transfer mechanisms effecting the movement of stable elements and radionuclides in terrestrial ecosystems are discussed, and methods used to simulate these processes by means of mathematical models are described to show how intake values are calculated for different radionuclides in the major ecological pathways leading to man. These data provide a basis for estimating potential internal radiation doses for comparison with the radiation -protection criteria established by recognized authorities; and this, in turn, provides a basis for recommending measures to ensure the radiological safety of the nuclear operation plan. (Authors) *Keywords:* EPA*, vegetation*, mammal*, nutrition/diet*, radiation*, methods*

433 **MASON, B.J., W.J. WIPPER, and V.D. LEAVITT. 1969. Tritium uptake following a thermonuclear test. In: *Environmental Contamination by Radioactive Materials,* SM-177/73, pp. 167-174.**

The mission of the Agrology Section of the US Public Health Service's Southwestern Radiological Health Laboratory is to develop radiation dose prediction models for components of man's food web that are likely to be affected by radioactivity resulting from the peaceful uses of nuclear explosives. At the Nevada Test Site this section has developed a farming facility which is located approximately two miles downwind from the nuclear crater resulting from the July 1962 detonation of the 100 kiloton thermonuclear device, Project Sedan. This report presents results of a study to evaluate the uptake of tritium by selected crops which are important to Nevada's agricultural economy. To determine the distribution of tritium from this detonation, a four-station transect was located along the axis from the Sedan crater to the farm facility. A graph of the 1968 tritium profile in the soil indicates a maximum concentration at a depth of approximately 70 cm. This depth is closely correlated with the depth of the maximum desert rainfall penetration for this area. Prior to cultivation, the tritium concentration in the soil surface plow layer of the farm ranged from 11.4 to 26.5 pCi/ml of soil water or 0.21 to 0.42 pCi/g of dry soil. Comparisons made between radishes (*Raphanus sativus*), potatoes (*Solanum tuberosum*), sweet corn (*Zea mays*), bush beans (*Phaseolus vulgaris*), watermelons (*Citrullus vulgaris*), and onions (*Allium cepa)* grown on the Nevada Test Site farm and similar produce purchased in the local markets indicated a significant difference between the tritium concentrations at the 991/2 confidence level. Many of the items purchased in the local markets were below the minimum sensitivity of the analytical system used in this study. The levels in the Nevada Test Site crops ranged from 2.0 to 3.0 pCi/g of dry tissue, or 3.00 to 4.87 pCi/m of tissue water. Although the concentrations found are of little significance as far as total dose to humans is concerned, this study has indicated that tritium is available over considerable periods of time and does not leave the environment via evaporation as has been suggested. (Authors) *Keywords:* radionuclide inventory*, annual plants*, mammal*, nutrition/diet*, radiation*

434 **MASON, B.J., K.W. BROWN, H.W. HOP, and C.L. MILLER. 1973. Desert vegetation uptake of tritium from Project Gasbuggy effluent. In: Nelson, D.J. (Ed.) *Radionuclides in Ecosystems*, Proceedings of the Third National Symposium on Radioecology (CONF-710501), pp. 177-182.**

Tritiated water vapor released to the atmosphere by flaring of the natural gas taken from the Project Gasbuggy cavity provided a unique tracer for evaluating atmospheric distribution of the activity and its subsequent uptake by native desert plants. Maximum uptake in plants was related to the effects of major terrain features on wind flow patterns. The maximum concentration of tritium was found to be in plants collected in the drainage wind pattern at 10 miles from the release points, and activity was from 5-10 times background levels found in vegetation collected elsewhere in the Southwest. (TPO) *Keywords:* vegetation*, radiation*

435 **MAXEY, G.B. 1968. Hydrogeology of desert basins. Ground Water 6: 10-22.**

Hydrologic systems in arid lands normally include a recharge area in mountains and a discharge area in lowlands often with an intermediate area of lateral flow between recharge and discharge areas. This system is often modified by local geologic, climatic, and physiographic factors. Most water-supply, contamination and disposal problems arise from a combination of features superimposed on this system by concentration of population and agricultural activity in the discharge areas. Also most of our data on the system comes from the lowlands and little data is available from the recharge areas. In the Great Basin two general categories of groundwater flow systems are recognized: (1) local flow systems where drainage areas are usually small, flow paths are relatively short, interbasin flow is uncommon, springs have large fluctuations in discharge, water temperature is low, and concentration of Na, K, C1, and SO is low, and (2) regional flow systems, where drainage areas are large, flow paths long, interbasin flow common, springs have large discharge, and the water is characteristically of higher temperature and contains higher concentrations of K, Na, CL, and $S0^4$. Hydrologic approaches used, in addition to conventional methods, include hydrologic budget, water-potential, and waterchemistry studies. Although detailed delineation of most flow systems in Nevada has not been accomplished, integration of hydrologic, geologic, and chemical methods allow approximate portrayal of many systems, both local and regional. Adequate methods upon which to base planning for optimum development of water resources in desert basins are now available. A conceptual model of optimal groundwater reservoir development illustrates how to determine optimum use of storage and perennial yield provided the use to which the water is to be put and the time of withdrawal are known. (Author) *Keywords:* geology*, hydrology*, wetlands*, methods*

436 **MAZA, B.G. 1991. Index of the Nevada Applied Ecology Group & Associated Publications Available in the Coordination and Information Center. DOE/NV/10630-13, CIC 0083300. Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV.**

The Coordination and Information Center (CIC) is an archive and research facility operated by Reynolds Electrical &

Engineering Co., Inc. (REECo) for the Department of Energy in Las Vegas, Nevada. The purpose of the CIC is to provide the public, the news media, governmental units, and other interested groups and individuals with data and documents on off-site radioactive fallout from nuclear weapons tests and other selected subjects. This center uses this type of index to assist researchers in the CIC archives. The index contains only those documents which are available through the CIC. These citations represent a significant portion of the principal research findings of the Nevada Applied Ecology Group. For ease of cross referencing these findings are grouped into entries containing the CIC Accession Number, principal author(s), title of the document, the originating agency publication number, originating agency name, total number of pages, and document date. The Principal Index lists the entries sequenced by the CIC-Accession Number. In addition four Ancillary Indexes arrange the entries alphanumerically: by primary and secondary subject categories, by the originating agency publication number (full cited works only), by all individual authors cited in the work, and by publication date (year and month). (Author) *Keywords:* NAEG*, bibliography*, radionuclide inventory*, vegetation*, invertebrate*, vertebrate*, ecology/ecosystem*, radiation*

437 MAZA, B.G., N.R. FRENCH, and A. P. ASCHWANDEN. 1973. Home range dynamics in a population of heteromyid rodents. Journal of Mammalogy 54: 405-425.

Seasonal, sexual, and temporal aspects of home range for pocket mice (*Perognathus formosus* and *P. longimembris*) and kangaroo rats (*Dipodomys merriami* and *D. microps*) were analyzed from records accumulated over 7 yr of monthly censuses of the rodents in 3 9-ha enclosures and one similar area not enclosed in the Mojave Desert (California, USA). The density function was used as a standard expression (in terms of sigma) to compare home ranges of different individuals, groups or species, or over time. Detailed analysis of 340 *P. formosus* in one enclosure showed that 16 shifted locations of their home range during the course of this study, and 99 were detected to make one or more long distance excursions beyond their home range. Compilation of all data gives an average representation of home range for this species in this environment to be a circle of radius 31 m, which will encompass 86% of the animals' activity. This radius is the 2-sigma value computed from the data. Size of home range differs between sexes and among years, with significant year by sex interaction. There is an inverse relationship between population density and size of home range. Home range size is not related to body size in the 4 species studied, which presumably occupy the same trophic level of the system. Shifts in home range and excursions outside the established home range occurred most frequently in males and most frequently in the reproductive season. (Authors) *Keywords:* mammal*, ecology/ecosystem*

438 McBRAYER, J.F., G.E. MAMOLITO, and P.J. FRANCO. 1975. The functional relationships among the organisms comprising detritus-based foodchains at the Rock Valley site. US/IBP Desert Biome Res. Memo. 75-30. Utah State University, Logan, 5 pp.

This report describes an incomplete study of the production ecology of detritus-based food chains in the northern Mohave Desert. Under laboratory conditions, the tenebrionid beetle *Eleodes armata* continued to reproduce as long as physical factors were held favorable, although the rate of egg-laying decreased with time. It was also found that hatch success was negatively correlated with egg-laying rate. Data are also presented on the growth rate and metabolism of larvae. The approach used to study the trophic relationships of soil microarthropods proved unsuccessful and the project was terminated before new approaches could be tried. Considerable data were collected on the availability of detritus within the system and these data are included. (Authors) *Keywords:* IBP*, invertebrate*, life history*, ecology/ecosystem*

439 McKINNEY, C.O., and F.B. TURNER. 1971. Genetic variation in irradiated and nonirradiated populations of the lizard *Uta stansburiana*. Radiation Research 47:530-536.

Analysis of allelic variation in continuously irradiated and nonirradiated populations of the lizard, *Uta stansburiana*, in Rock Valley, Nevada, revealed no significant differences in relative allele frequencies at 19 loci controlling selected proteins. The irradiated population did not differ significantly from control populations in 3 conventional measures of genetic variability. (Authors) *Keywords:* reptile*, radiation*

440 MEDICA, P.A. 1988. Results of work completed on the Basic Environmental Compliance and Monitoring Program (BECAMP) on reptiles and small mammals at the Nevada Test Site in 1987. Reynolds Electrical & Engineering Co., Inc. Las Vegas, NV.

In the spring and summer of 1987 lizard and small mammal studies were initiated on the Nevada Test Site under the BECAMP program. Surveys of the natural populations were conducted in three major valleys, (Jackass Flats, Frenchman

Flat, and Yucca Flat) to determine the condition and stability of resident species in pristine habitat on permanent study plots. Similar sampling was carried out on one subsidiary plot (natural burn area), and a matching control plot in undisturbed habitat. During the fall of 1987 portions of northwest Frenchman Flat were surveyed to determine presence of the desert tortoise. (Author) *Keywords:* perturbations*, reptile*, mammal*, desert tortoise*, ecology/ecosystem*

441 MEDICA, P.A. 1990. Noteworthy Mammal Distribution Records for the Nevada Test Site. Great Basin Naturalist Memoirs 50(1):83-84.

This publication reports the range extension of three mammal species on the Nevada Test Site (NTS). Live capture of two *Mustela frenata nevadensis* in Rock Valley in 1988 extends this species' known range approximately 58 km south of its previous known locality. One dead specimen on Holmes Road in 1988, a cited trapping 8.9 km northwest of Whiterock Spring in 1930-31, and an additional sighting on Pahute Mesa of *Urocyon cinereoargenteus scottii* in 1986 verifies that this species occurs on the NTS. Live capture of three *Microdipodops megacephalus sabulonis* in 1988 on Pahute Mesa extends the species' known distribution approximately 32.2 km southwest of Kawich Valley and on to Pahute Mesa. (CAW) *Keywords:* mammal*, ecology/ecosystem*

442 MEDICA, P. 1992. Status of Reptiles in 1988. In: Status of the Flora and Fauna on the Nevada Test Site, 1988. Hunter, R.B. (Compiler), DOE/NV/10630-29, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 59-96.

Reptile studies under the Basic Environmental Compliance and Monitoring Program were initiated in 1987 to document the relative number or density of the common at various locations on the Nevada Test Site (NTS), and to document changes which may occur over time. Desert tortoise growth studies initiated in Rock Valley (NTS) are being continued, and free-ranging tortoises throughout NTS will be enumerated on an ongoing basis. The BECAMP reptile sampling project in 1988 included surveys of natural populations of lizards in three major valleys (Jackass Flats, Frenchman Flat, and Yucca Flat) and on Pahute Mesa. The resident reptile species on the BECAMP baseline monitoring plots were sampled to provide data on species composition and relative density, which eventually will provide information on the stability and condition of the populations under baseline conditions. *Uta* sampling was conducted on seven subsidiary plots in Yucca Flat in 1988 (T1 Blast area and control; T3 Blast area, 3B Consolidation Site and control; and a natural burn area and nearby unburned area). Desert tortoises *Gopherus agassizii* were recaptured in Rock Valley, maintaining records on animals first marked in the early 1960s (Medica et al. 1975; Turner et al. 1987). As part of the BECAMP studies at the NTS, the tortoises in the Rock Valley study area will be recaptured at least yearly. Tortoises were also searched for, marked and released in Frenchman Flat, northern Jackass Flats, Mercury Valley and Rock Valley. (Authors) *Keywords:* perturbations*, desert tortoise*, reptile*, ecology/ecosystem*, life history*

443 MEDICA, P.A., and F.B. TURNER. 1976. Reproduction of *Uta stansburiana* (Reptilia, Lacertillia, Iquanidae) in Southern Nevada. Journal of Herpetology, 10(2):123-128.

Monthly mean clutch sizes of *Uta stansburiana* in southern Nevada were measured over a ten-year period. Overall mean clutch sizes of female *Uta* <12 months of age were 4.40 (March-April), 3.80 (May), 3.04 (June), and 2.65 (July). Overall means of yearling females (<12 months of age) were about 82-90% of those of older females between April and June. Reproduction by *Uta* in 1973 surpassed that observed in any of nine previous years. The mean size of the first clutch laid by older females was 5.35, and some females deposited up to eight eggs. The minimum number of clutches laid was four and the maximum seven. The net reproductive rate (R_o) estimated for 1973 was 2.34, exceeding an earlier estimate for 1966 (1.65). (Authors) *Keywords:* reptile*, life history*

444 MEDICA, P.A., and F.B. TURNER. 1984. Natural longevity of iquanid lizards in southern Nevada. Herp. Review 15(2):34-35.

This article provides a table and discussion of the observed life spans of four species of iquanid lizards in Rock Valley, Nye County, Nevada where sampling occurred regularly between early March and September 1962-1973. These observations indicate natural life spans of about 94 months in *Cnemidophodorus*, 188 months in *Crotaphytus*, 82 months in *Phrynosoma,* and 58 months in *Uta.* (CAW) *Keywords*: reptile*, life history*

445 MEDICA, P.A., R.B. BURY, and R.A. LUCKENBACK. 1980. Drinking and Construction of Water Catchments by the Desert Tortoise, *Gopherus agassizii*, in the Mojave Desert. Herpetologica 36(4):301-304.

Desert tortoises, *Gopherus agassizii*, generally were active in the spring and fall. They often became active during and after infrequent showers and thunderstorms, and drank from temporary pools of standing water even when air temperatures were suboptimal (9-15 °C). In several instances tortoises constructed shallow catchment basins which held water for as long as six hours. Thus tortoises can obtain drinking water by modifying their environment. Following small amounts of rainfall (5.6 mm) in July 1976, six tortoises increased an average of 9.2% in body weight; this increase was due to ingestion of water. Drinking may be an important source of water for this species. (Authors) *Keywords:* desert tortoise*, ecology/ecosystem*

446 MEDICA, P.A., R.B. BURY, and F.B. TURNER. Growth of the desert tortoise (*Gopherus agassizi*) in Nevada. 1975. Copeia 4:639-643.

Between 1963 and 1973 growth of the desert tortoise (*Gopherus agassizi*) in southern Nevada averaged about 9 mm per year. Yearly increments were estimated for 5 years (1969-1973) and ranged from a low of 1.8 mm in 1972 to a high of 12.3 mm in 1969. Growth was greatest following winters of high precipitation, which resulted in increase production of winter annuals in the spring. Growth of tortoises generally occurred between April and July. The weight, W (g), of tortoises may be estimated as $W = 0.000258X^{2.98}$ with X the plastron length in mm. (Authors) *Keywords:* desert tortoise*, life history*

447 MEDICA, P.A., O.L. HAWORTH, and M.S. KELLY. 1990. Geographic Distribution: *Eumeces gilberti rubricaudatus* (Western Redtail Skink), Herpetological Review 21(2):40.

Three specimens collected on the Nevada Test Site are reported. These specimen records extend the range of this species of skink by about 130 km west-northwest of the Sheep Range; 135 km northwest of Lee Canyon, Spring Range; and 65 km northeast of Grapevine Peak. (WKO) *Keywords:* reptile*, ecology/ecosystem*, taxonomy*

448 MEDICA, P.A., G.A. HODDENBACH, and J.R. LANNOM, Jr. 1971. Lizard sampling techniques. Rock Valley Miscellaneous Publications, No. 1, 55 pp.

Describes lizard sampling techniques used successfully by UCLA on the Nevada Test Site. Includes methods for estimating density and assessing reproduction and includes an appendix of sampling equipment and computer techniques. (TPO) *Keywords:* reptile*, ecology/ecosystem*, life history*, methods*

449 MEDICA, P.A., T.P. O'FARRELL, and E. COLLINS. 1981. Survey of Yucca Mountain, Forty-Mile Canyon, and Jackass Flats in Nye County, Nevada for Desert Tortoise, *Gopherus agassizi*. EG&G Energy Measurements, Santa Barbara Operations Report No. EGG 1183-2483.

Surveys were conducted in August 1981 to determine distribution of the desert tortoise (*Gopherus agassizi*) on the lower eastern slope of Yucca Mountain west of Forty-Mile Canyon and along the major access roads which lead through Jackass Flats to Yucca Mountain, Nevada Test Site, Nevada. Positive evidence of the presence of desert tortoise was observed in two locations on Yucca Mountain between 1,040 and 1,160 m (3,400 to 3,800 ft) in *Larrea-Ambrosia* vegetation. The relative density of tortoises was estimated to be 10 per square mile at one location, and 90 to 100 per square mile at the second. (Authors) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*

450 MEDICA, P., M. SAETHRE, and R.B. HUNTER. 1994. Recovery of a desert community after fire in the northern Mojave. In: The Desert Tortoise Council Proceedings of 1994 Symposium, pp. 68-92. Desert Tortoise Council, Inc., San Bernadino, CA.

Flora and fauna were censussed in 1987, 1990, and 1993 on a burned area and nearby control to examine fire effects and recovery. The 1985 lightning-caused fire was followed by drought in 1988 to 1991. 1987 was a good year for annual plant growth (burn = 74g/m^2), but in 1990 there was no germination. Winter precipitation in 1993 was twice that of 1987, and nearly twice as many species but lower biomass was recorded (46g/m^2) than 1987. On the control, biomass was 52g/m^2 in 1987, 0 in 1990, and 65g/m^2 in 1993. Exotic species *Bromus rubens, Erodium cicutarium*, and *Amsinckia tessellata* were abundant in 1987 and 1993. Shrubs and bunch grasses died or died back in 1990 followed by increases in cover and live volume in 1993. Growth from 1990 to 1993 was proportionally greater on the burn where total cover increased from 1% to 5% compared to 13 to 17% on the control. Grasses made up 88% of the perennial plants in the burn and 37% in the unburned transect. Crown and root sprouters, *Ephedra nevadensis, Lycium andersonii*, and *Stipa speciosa*, prospered after the fire. On the control in 1990, 97% of the bunch grasses died due to drought compared to only 60% on the burn where competition for resources was lower. *Hymenoclea salsola* invaded the edges of the burned area by 1993. Rodents on the burn in 1987 were dominated by *Dipodomys merriami* while *Perognathus longimembris* was most common on the undisturbed area. Species diversity on the control was higher although numbers captured at both sites were similar. In 1990 decreases occurred at both sites, although the burn appeared to provide better forage as this area had more animals, even though plant cover was lower. 1993 results were similar to 1987; however, *Chaetodipus formosus* replaced *P. longimembris* as most common on the control. No adult *Uta stansburiana* were observed on the burn during August 1987 while five were captured on the control. Hatchlings numbered 32 on burn and 33 on control. Similar results occurred in 1988, although 4 adults were captured on the burn in the summer compared to 11 on the control. Fewer adults in spring 1990 (11) affected hatchling production on the burn, with less than half as many (15) as on the control (36). Population size of adults on the control (38) appeared to be unaffected by the drought, but fewer hatchlings were produced than in 1988. In 1993 adult and hatchling numbers were back to 1988 levels on the burn while the control had numbers twice that of 1988. The burned area appeared to be impacted by the drought as subsequent recovery of vertebrates was hindered, apparently by lack of plants for cover, forage and insect supply. Other sites nearby that were disturbed over the past 40 years by blasting, blading, and compacting have been slow to recover, possibly because soil fertility was depleted by those activities. By comparison, the burned area's revegetation and recovery has been rapid. (Authors) *Keywords:* climate*, perturbations*, invasive species*, annual plants*, perennial plants*, reptile*, mammal*, ecology/ecosystem*

451 **MEDICA, P.A., F.B. TURNER, and D.D. SMITH. 1973. Effects of radiation on a fenced population of horned lizards *(Phrynosoma platyrhinos)* in southern Nevada. Journal of Herpetology 7:79-85.**

Between 1964 and 1966 minimum spring densities of horned lizards ranged from 1.0-2.5/hectare (ha) in three 8 ha enclosures in Rock Valley, Nevada. Minimal survival of hatchling horned lizards to the age of 8 months was about

26-38 percent. Annual minimal survival of older lizards was 50-60 per cent. Female horned lizards usually laid one clutch of eggs per year, but multiple clutches were observed in 1969. Conversely, no reproduction was observed in 1970. The maximum life span of horned lizards is at least 94 months. One of the enclosures was subjected to continuous gamma irradiation from a centrally located source of Cs-137. Between 1964 and 1966 numbers of horned lizards declined in all 3 plots. Between 1967 and 1970 numbers of horned lizards increased in the two control areas, but continued to decline in the irradiated plot. Female sterility owing to regression of ovaries is judged to be the cause of the population decline. Similar radiation effects have previously been observed among leopard lizards (*Crotaphytus wislizenii*), whiptail lizards (*Cnemidophorus tigris*), and side-blotched lizards, (*Uta stansburiana*). (Authors) *Keywords:* reptile*, life history*, radiation*

452 **MEDICA, P.A., F.B. TURNER, and D.D. SMITH. 1973. Hormonal induction of color change in female leopard lizards, *Crotaphytus wislizenii*. Copeia, 1973, No. 4, pp. 658-661.**

Follicle stimulating hormone will induce red-orange pigmentation in nonovariectomized female leopard lizards in 7-21 days depending upon the season. Progesterone is judged to be an important hormone in the process of color change, and will bring about pigmentation in the absence of ovarian tissue. Estrogen alone has no apparent effect on color change, but when administered before progesterone it appears to have a priming effect. (Authors) *Keywords:* reptile*, physiology*

453 **MEDICA, P., M. SAETHRE, R. HUNTER, and J. DRUMM. 1994. Trends in Reptile Populations on the Nevada Test Site. In: Status of the Flora and Fauna on the Nevada Test Site, 1989-91. Hunter, R.B. (Compiler), DOE/NV/11432-57, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 1-49.**

During the period 1989 through 1991, reptile populations were monitored on the Nevada Test Site (NTS). The nearly ubiquitous lizard *Uta stansburiana* was monitored with mark-recapture techniques on an NTS-wide set of permanent plots, established in both disturbed areas and nearby undisturbed areas. Other species of lizards were monitored on a selected portion of these plots with transect techniques. A long-term study of fenced desert tortoises in Rock Valley was continued, and free-roaming tortoises were marked and measured whenever encountered. On the areas studied, there were two prime factors affecting lizard populations. On areas cleared of vegetation by any agent (fire, weapons tests, scraping, gophers) the population of *Uta stansburiana* declined severely or disappeared altogether. Reinvasion by hatchlings and adults occurred, but summer predation rates in the absence of cover appeared to prevent successful recolonization. Transect studies suggested the decline did not occur in other common species, most of which are predators of *Uta*. Drought was the second major influence on lizard populations. Severe drought was coincidental with a marked decline in reproduction in 1989, followed in 1990 by an overall decline in populations to about half of 1987-88 levels. The decline in overall numbers, which occurred in all species, was tempered by improved survival of lizards hatched before the drought began. All 17 desert tortoises (*Gopherus agassizii*) in the Rock Valley enclosures survived the drought, although annual plants were absent for two years. Growth was minimal in 1989 and 1990, the most severe drought years. None showed any symptoms of upper respiratory tract disease. By the end of 1991, 75 free-roaming tortoises were marked and measured. These also appeared to be disease-free. (Authors) *Keywords:* perturbations*, desert tortoise*, reptile*, ecology/ecosystem*, life history*

454 **MEHUYS, G.R., L.H. STOLZY, J. LETEY, and L.V. WEEKS. 1974. Evaluation of Critical Soil Properties Needed to Predict Soil Water Flow Under Desert Conditions. 1974. US/IBP Desert Biome Res. Memo. 74-45. 14 pp.**

Hydraulic conductivity and soil water diffusivity have been measured for "Rock Valley" gravelly loamy sand and Tubac and Rillito gravelly sandy loams over a soil water pressure range of -0.05 to -50 bars, using a transient outflow method. A secondary objective of this study was to determine whether moisture transmission properties of these stony soils could be evaluated using samples of the same soils in which the stony fraction (>2 mm) had been excluded. If expressed as a function of soil water pressure, hydraulic conductivity values were similar whether or not stones were present. When K was expressed as a function of volumetric water content (⊖), conductivities were higher for a given water content when stones were present. A simple correction of water contents of stone-free samples, based on the stone volume of each soil, adequately accounted for differences observed when water contents were computed on a total volume basis. Moisture movement induced by thermal gradients in sealed soil columns was studied under steady-state conditions. For Tubac and Rillito soils, water contents in the soil columns remained unchanged during the experiments because the initial water contents were too high. In studies with "Rock Valley" soil, thermal moisture diffusivity L_{wq} decreased from 14.0 to 1.3 x 10^{-3} $cm^2 hr^{-1} deg^{-1}$ as ⊖ decreased from 0.14 to 0.08, indicating that much of the moisture movement from hot to cold regions probably occurred in the liquid phase. However, the values of L_{wq} were scattered and the influence of stones on this coefficient could not be determined from the experimental data. A qualitative evaluation was made of the role larger stones may play in the water economy of desert environments by providing water condensation surfaces on their undersides. Condensation of water vapor could occur whenever the temperature beneath a stone is lower than the dew point temperature. Two experiments -- one involving a buried stone, the other a surface stone -- were set up to measure the temperature distributions under and around stones submitted to a diurnal heat wave. Temperatures were monitored both in air dry and moist soil. Only when a stone was placed on the surface of air dry soil were temperatures lower than in the surrounding soil. A maximum difference of 7 C was attained a few hours after heating began. During the cooling period, the trend was reversed. When soil is sufficiently dry so that water moves mainly in the vapor phase, condensation could occur during the early part of the day. Whether such moisture accumulation is of significance to desert fauna and flora warrants further investigation. (Authors) *Keywords:* IBP*, hydrology*, soil property*

455 **MILLS, H.L., and L.M. SHIELDS. 1961. Root absorption of fission products by *Bromus rubens* L. from the AEC Nevada Test Site soil contaminated by an underground nuclear explosion. Radiation Botany 1:84-91.**

The extent of accumulation in the above-ground plant parts resulting from fission products was assessed. The experimental plant chosen, *Bromus rubens*, was a grass with a fibrous root system which characteristically was located in soil retaining most of the fallout materials. The soil was from the crater of the underground nuclear detonation, Blanca Event, October 30, 1958. It does not seem appropriate in the case of shallow-rooted plants to make predictions of plant uptake on the basis of any distinction between soluble and exchangeable portions in soils. (HP) *Keywords:* invasive species*, annual plants*, nutrition/diet*, radiation*

456 **MISPAGEL, M.E. 1978. The Ecology and Bioenergetics of the Acridid Grasshopper, *Bootettix punctatus* on Creosotebush, *Larrea Tridentata*, in the Northern Mojave Desert. Ecology (59):779-788.**

A 5-yr investigation was conducted of the population structure and bioenergetics of the host specific acridid, *Bootettix punctatus*, on creosotebush, *Larrea tridentata*, [in Rock Valley] in the northern Mojave Desert of southern Nevada. Maximum densities ranged from 330-1,360 insects/ha in mid-summer on a shrub density of 1,000 plants/ha. Energy used for respiratory maintenance accounted for 55-68% of the energy assimilated by the populations. Assimilation was 20- 23% of the 207-1,681 J/m^2 energy ingested per season. The estimated proportion of the host plant's annual leaf biomass consumed during the first 3 yr of this study ranged from 0.8-1.9%. Nutrient availability in *Larrea* as a function of available soil moisture is suggested as a possible factor influencing the survivorship of early instar nymphs and of the population as a whole. Normal effects on the host plant due to phytophagy are probably negligible but, under certain climatic conditions, phytophagy by *Bootettix* in late summer may stimulate primary production or improve the drought resistance of the shrub by defoliation. *Keywords:* invertebrate*, perennial plants*, ecology/ecosystem*, nutrition/diet*

457 **MITCHELL, D.L. 1984. Evaluation of Habitat Restoration Needs at Yucca Mountain, Nevada Test Site, Nye County, Nevada. EGG 10282-2030, S-763-R. EG&G Energy Measurements, Goleta, CA, pp.12.**

Adverse environmental impacts due to site characterization and repository development activities at Yucca Mountain must be minimized and mitigated according to provisions of the Nuclear Waste Policy Act of 1982 and the National Environmental Policy Act. Although the exact area of disturbance is unknown it is estimated to be about 300-400 acres. Planned habitat restoration at Yucca mountain will mitigate the effects of plant and animal habitat loss, over time by increasing the rate of plant succession on disturbed sites. Restoration program elements should combine the appropriate use of native annual and perennial species, irrigation, and/or water harvesting techniques, and salvage and reuse of topsoil. Although general techniques are well-known, specific program details must be worked out empirically on a site-specific basis over the period of site characterization an any subsequent repository development. Large-scale demonstration areas set up during site characterization will benefit both present abandonments and, if the project is scaled up to include repository development, larger facilities areas including spoils piles. (Author/WKO) *Keywords:* YMSCO*, perturbations*, revegetation*

458 **MOOR, K.S., and W.G. BRADLEY. 1974. Ecological Studies of Vertebrates in Plutonium-Contaminated Areas of the Nevada Test Site. In: *The Dynamics of Plutonium in Desert Environments*. Dunaway, P.B., and M.G. White (Eds.). NVO-142, U.S. Atomic Energy Commission Nevada Operations Office, Las Vegas, NV, pp. 187-212.**

Various standard census methods were employed during the period March, 1972 August, 1973, to obtain a qualitative and quantitative inventory of the vertebrate biota in three plutonium-contaminated study areas of the Nevada Test Site (NTS). Data are presented on the vertebrate composition, relative abundance, and seasonal status in the study areas. More detailed data on rodent populations are included for Area 13. Five species of snakes have been observed in these study areas. Additional species, although not observed due to their nocturnal habits, are undoubtedly present. The insectivorous lizards, *Cnemidophorus tigris* and *Uta stansburiana*, are the most abundant lizards in all of the study areas, whereas *Callisaurus draconoides* is only abundant in Area 5. The carnivorous lizard, *Crotaphytus wislizeni*, is found in all three study areas. Seasonally, birds are an important group in all study areas. Species richness, seasonal status, and relative abundance varied greatly between the years 1972-1973. The Horned Lark is the only common-to-abundant resident, while common-to-abundant migrants during spring, 1973, were Black-throated Sparrows, Mourning Dove, and Western Kingbird. Rodents common to all study areas were: *Dipodomys microps*, *Dipodomys merriami*, *Perognathus longimembris* and *Ammospermophilus leucurus*. In addition to the four common species, *Microdipodops megacephalus* and *Perognathus parvus*, characteristic of the Great Basin Desert, were found in Area 13. (Authors) *Keywords:* NAEG*, bird*, reptile*, mammal*, ecology/ecosystem*, radiation*

459 **MOOR, K.S., and W.G. BRADLEY. 1987. Radioecology of Small Animal Populations Inhabiting a Nuclear-Event Site at Nevada Test Site. In: *The Dynamics of Transuranics and Other Radionuclides in Natural Environments.* Howard, W.A., and R.G. Fuller (Eds.). NVO-272, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 517-525.**

Radioecology studies of small vertebrates at LITTLE FELLER II, a nuclear event site, began in spring 1977 and continued intermittently until September 1980. This report summarizes data collected during that time on vertebrate species inventories, rodent populations, and radionuclide concentrations in tissues of rodents inhabiting the LITTLE FELLER II site. Comparisons are made with earlier work done at Safety-shot areas at NTS. Radioanalytical results of 180 tissue samples from 60 animals are presented. Animals whose movements in the study area had been monitored from 2 weeks to 18 months were periodically collected for tissue analysis. Mean concentrations of radionuclides in the pelt, GI tract, and carcasses of the dominant rodent, *Dipodomys* spp., are presented. Tissue concentrations of gamma-emitting radionuclides and ^{90}Sr were at background levels. Concentrations of Pu and Am in tissues were highly variable even when the animals were grouped by residence time in the study area and by soil activity strata in which they resided. However, there was some evidence that animals inhabiting higher activity strata had higher concentrations in the carcasses. Concentrations of Pu and Am in the GI tract were generally two orders of magnitude higher than in the carcass. Pu/Am ratios in the three tissues were similar to those reported for soils at the LITTLE FELLER II site. (Authors) *Keywords:* NAEG*, vertebrate*, mammal*, radiation*

460 **MOOR, K.S., S.R. NAEGLE, and W.G. BRADLEY. 1977. ^{239}Pu and ^{241}Am Contamination of Small Vertebrates in NAEG Study Areas of NTS and TTR. In: *Environmental Plutonium on the Nevada Test Site and Environs*. White, M.G., P.B. Dunaway, and W.A. Howard (Eds.). NVO-171, Nevada Applied Ecology Group, U.S. Energy Research & Development Administration, Las Vegas, NV, pp. 193-217.**

Nevada Applied Ecology Group ecological studies of small vertebrates in three plutonium (Pu) contaminated study areas of Nevada Test Site began in Spring, 1972, and were expanded to include four areas of Tonopah Test Range in Fall, 1973. Much of the basic inventory and ecological data on small vertebrates have been previously reported. This progress report consists primarily of presentation and analysis of radioanalytical data on rodents and lizards from Area 11-C, Nevada Test Site. In addition, methodology and preliminary results of initial hematologic studies are presented. *Dipodomys microps* is a dominant rodent species in all study areas. Concentrations of ^{239}Pu and ^{241}Am in pelt, GI tract, and carcass of 74 resident *D. microps* from five study areas were determined. The only consistent trend evident was that carcass burdens were lower than pelt or GI tract burdens by a factor of 10^2. Mean ratios of Pu/Am in tissue aliquots were variable, and many were significantly different than ratios in soil or vegetation samples. Rodents which were resident near GZ, Area 11-C, in high activity strata (>25,000 CPM ^{241}Am) had higher Pu concentrations in the three tissue components examined than rodents which resided in lower activity strata (<25,000 CPM Am) at greater distances from GZ. Whereas Pu concentrations in small vertebrates were variable and did not differ significantly between trophic categories, Pu/Am ratios in carcasses of insectivore-omnivores were significantly higher (P<.0l) than mean ratios reported in soil and vegetation samples from Area 11-C. Studies on food sources and microhabitats frequented by rodents are needed before Pu and Am uptake can be properly evaluated. Trapping data indicate that resident rodent species and most rodent populations were fewer in number in the higher Pu activity strata in Area 11-C. Therefore collections of adequate samples of resident rodents from the vicinity of GZ will require extended collecting effort encompassing several reproductive seasons. Preliminary results of hematologic studies of rodents in Area 11-C indicate that there is a correlation between Pu body burdens and depressions in some leukocyte counts. Regression analysis revealed a significant (P<.01) reduction in relative number of lymphocytes, with an increase in Pu carcass burdens of *Dipodomys microps* and *Perognathus longimembris*. Leukocyte counts were significantly lower (P<.01) with an increased Pu carcass burden in *D. merriami*. More data from animals with high Pu tissue burdens are needed before effects of Pu on the hemopoietic system of rodents can be properly evaluated. (Authors) *Keywords:* NAEG*, reptile*, mammal*, physiology*, radiation*

461 **MOOR, K.S., W.G. BRADLEY, J.S. MILLER, and S.R. NAEGLE. 1976. Standard Nevada Applied Ecology Group Procedures For Collection of Small Vertebrates From Intensive Study Areas. In: *Nevada Applied Ecology Group Procedures Handbook for Environmental Transuranics*. White, M.G., and P.B. Dunaway (Eds.). NVO-166, U.S. Energy Research and Development Administration Nevada Operations Office, Las Vegas, NV, pp. 139-148.**

This paper describes the standardized procedures for inventory, census, and collection of small vertebrates used by Nevada Applied Ecology Group (NAEG) researchers conducting studies on the potential effects of residual plutonium (Pu) in the soil, plants, and biota of selected areas of the Nevada Test Site (NTS). (CAW) *Keywords:* NAEG*, methods*, vertebrate*, radiation*

462 **MOOR, K.S., W.G. BRADLEY, J.S. MILLER, and S.R. NAEGLE. 1976. Standard Nevada Applied Ecology Group Procedures for Preparation of Small Vertebrates from Intensive NAEG Study Areas for Radioanalysis and Histopathological Examination. In: *Nevada Applied Ecology Group Procedures Handbook for Environmental Transuranics*. White, M.G., and P.B. Dunaway (Eds.). NVO-166, U.S. Energy Research and Development Administration Nevada Operations Office, Las Vegas, NV, pp. 149-153.**

This paper describes the standard protocol for the radioanalysis of tissues of small mammals and lizards sampled from study areas at various known distances from ground zero in Pu-contaminated areas. It also describes body measurements taken for sampled vertebrates and the procedures used to obtain baseline hematological data from animals collected off-site and in NAEG Intensive Study Areas. (CAW) *Keywords:* NAEG*, methods*, reptile*, mammal*, physiology*, radiation*

463 **MORK, H.M. 1970. Redistribution of plutonium in the environs of the Nevada Test Site. USAEC Report UCLA 12-590, 29 pp.**

Data is presented on redistribution of plutonium as indicated by changes in the concentrations of gummed papers, air filters, soil and animal samples collected in 1956 and 1958. The airborne concentrations were significantly higher in one area than they were two years previous. The plutonium content of the soil ranged from less than one microgram to 2,000 micrograms per square meter in the two areas studied. Some redistribution was occurring. Plutonium was associated with the liver, the lungs, and the bone of animals in the study areas. The maximum values observed in 1958 were 0.16 and 57.5 disintegrations per minute per animal for the liver and the lungs, respectively, and 2.62 disintegrations per minute per gram of bone ash. (Author) *Keywords:* radionuclide inventory*, vertebrate*, radiation*

464 MORK, H.M., A. WALLACE, and E.M. ROMNEY. 1980. Effect of Certain Plant Parameters on Photosynthesis, Transpiration, and Efficiency of Water Use. Great Basin Naturalist Memoirs 4:117-120.

Rates of gaseous exchange were measured on selected desert shrubs native to the northern Mojave Desert to determine effects of varying chamber temperature, CO_2 concentration, relative humidity, and root temperature in preliminary studies. Results indicate that changes in these parameters produced differences in the rates of photosynthesis and transpiration. *Ceratoides lanata* (Pursh) took up CO_2 almost equally at 25 and 39 C. Doubling the CO_2 concentration in the below-ambient range roughly doubled photosynthesis rates in *C. lanata*. Very small changes in relative humidity had marked changes in the photosynthesis and transpiration rates of four species studied, with greater effect on transpiration. Photosynthesis and transpiration increased, and water-use efficiency decreased in two species as soil temperature was increased from 9 to 29 C. (Authors) *Keywords:* perennial plants*, physiology*

465 MOUNT, M.E. 1977. NAEG Area 11 Sites A, B, C, and D, Report of Vegetation Results. In: *Environmental Plutonium on the Nevada Test Site and Environs.* White, M.G., P.B. Dunaway, and W.A. Howard (Eds.). NVO-171, Nevada Applied Ecology Group, U.S. Energy Research & Development Administration, Las Vegas, NV, pp. 79-110.

This memorandum documents the final McClellan Central Laboratory (MCL) results from plutonium, americium, and uranium analyses of Nevada Applied Ecology Group (NAEG) Area 11 vegetation samples. Specific activities of ^{238}Pu, ^{239,240}Pu, ^{241}Am, and ^{235}U are reported for each sample. (Authors) *Keywords:* NAEG*, vegetation*, radiation*

466 MUELLER, J.M., and K.K. ZANDER. 1994. Nevada Test Site Tortoise Population Monitoring Study Final Report. EGG-11265-1113, EG&G Energy Measurements Las Vegas Area Operations, Las Vegas, NV, 6 pp.

A Tortoise Population Monitoring Study was initiated to determine and monitor the density of desert tortoises (*Gopherus agassizii*) on the Nevada Test Site. Quadrat sampling was conducted following methodology described in the Draft Desert Tortoise Recovery Plan (FWS, 1993). So few tortoises were found that densities could not be calculated. Based on estimates of capture probabilities and densities from other studies, it was determined that 1-km^2 (0.4 mi^2) plots did not contain enough tortoises for estimating densities with the Recovery Plan methods. It was recommended that additional surveys on the Nevada Test Site using those methods not be conducted. Any future efforts to monitor desert tortoise densities should start by identifying other possible methods, determining their relative power to detect changes, and estimating their cost. (Authors) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*, methods*

467 MUELLER, J.M., K.R. NAIFEH, D.L. RAKESTRAW, K.R. RAUTENSTRAUCH, and K.K. ZANDER. 1994. Reproductive Characteristics of Desert Tortoises at Yucca Mountain, Nevada. In: The Desert Tortoise Council Proceedings of 1994 Symposium, p. 169. Desert Tortoise Council, Inc., San Bernadino, CA.

We are monitoring the reproductive success of desert tortoises (*Gopherus agassizii*) at Yucca Mountain and Calico Hills, Nevada, to assess impacts of the Yucca Mountain Site Characterization Project on this species. During 1991 and 1992 we developed methods for finding desert tortoise nests. Thirty-one nests were found in 1992 and 1993. Clutch size ranged from 1 to 10 eggs ($\bar{x}$=4.9 eggs, SD=2.0) and individual egg mass ranged from 17.8 to 41.7 g ($\bar{x}$=31.5 g, SD=4.1, n=147). Time to emergence of first hatchling was 79 to 112 days ($\bar{x}$=91 days, SD=8.4, n=27). Eggs in one nest were eaten by a predator. Eighty-seven percent of the eggs not eaten by predators (n=146) produced viable offspring. (Authors) *Keywords:* YMSCO*, desert tortoise*, life history*

468 MUELLER, J.M., K.R. SHARP, K.K. ZANDER, D.L. RAKESTRAW, K.R. RAUTENSTRAUCH, and P.L. LEDERLE. 1998. Size-Specific Fecundity of the Desert Tortoise (*Gopherus agassizii*). Journal of Herpetology 32:313-319.

We determined the annual fecundity of desert tortoises using x-rays from 1993 through 1995 at Yucca Mountain, Nevada.

The smallest tortoise to reproduce was 209 mm carapace length (CL); eleven smaller tortoises did not reproduce. The mean age of first reproduction was estimated to be 19-20 years. Clutch size and annual fecundity were related to female size, but annual clutch frequency was not. Clutch size ranged from 1 to 10 eggs; annual clutch frequency ranged from 0 to 2. Mean clutch size of tortoises with a single clutch was 0.9 eggs larger than that of tortoises with two clutches. Annual fecundity ranged from 0 to 16 eggs. Predicted annual fecundity was three eggs for a 208 mm CL tortoise and increased by one egg for each 7 mm increase in CL. Annual fecundity of tortoises in this study was compared with that of tortoises studied in Goffs, California, during 1983-1985. The regressions of fecundity on female size had similar slopes, but tortoises at Goffs produced an average of 4.5 eggs more than tortoises of the same size in our study. Tortoises at Goffs, however, were significantly smaller than tortoises in our study. (Authors) *Keywords:* YMSCO*, desert tortoise*, life history*

469 **MULLEN, R.K. 1970. Respiratory metabolism and body water turnover rates of *Perognathus formosus* in its natural environment. Comp. Biochem. Physiol. 32:259-265.**

Gravimetric and isotopic determinations of the respiratory and water metabolism of *Perognathus formosus* in the laboratory are in substantial agreement with values which are known from other heteromyid species obtained under similar conditions. Isotopic determinations in the field of these parameters in *P. formosus* yield respiratory metabolic values reflective of an active animal in a non-post-absorptive state. Body water turnover rates range from 2.4 to 4.0 times greater than those previously measured in heteromyid rodents. With the ability to measure metabolism in natural environments, continued reliance upon values obtained from laboratory experiments would seem limiting when insights into the physiological ecology of a species are sought. (Author) *Keywords:* mammal*, physiology*

470 **MULLEN, R.K. 1971. Energy metabolism and body water turnover rates of two species of free-living kangaroo rats, *Dipodomys merriami* and *Dipodomys microps*. Comparative Biochemistry and Physiology 39: 379-390.**

The energy metabolism and comparative body water turnover rates of two species of kangaroo rats, *Dipodomys merriami* and *Dipodomys microps* were measured in the natural environment over a 1-yr period with the $D_2{}^{18}0$ method. In addition to yielding energy metabolism data indicative of active, non-postabsorbtive animals, the results suggest that both species undergo diurnal torpor during periods of cold stress. Comparative water metabolism data indicate that *D. merriami* possesses a more conservative body water turnover rate than does *D. microps*. The $D_2{}^{18}0$ method of studying animal energy metabolism in the natural environment yields data not obtainable through conventional laboratory methods. It is preferable, therefore, that where practicable this method be employed in investigations of animal physiological ecology unless there is reasonable assurance that laboratory methods are adequate. (Author) *Keywords:* mammal*, physiology*

471 **MULLEN, R.K. 1971. Energy metabolism of *Peromyscus crinitus* in its natural environment. Journal of Mammalogy 52:633-635.**

The energy metabolism of free-ranging canyon mice, *Peromyscus crinitus*, was measured using the $D_2{}^{18}0$ method. Estimates of oxygen consumption in January and February showed more variation between them than would have been predicted based on small differences in ambient temperature. The data suggest that some canyon mice may have undergone diurnal torpor or a period of reduced body temperature in response to either cold stress or shortage of food, or both. This technique does not provide data that would help define which of the two physiologic states the animals were in during the period of measurement. (TPO) *Keywords:* mammal*, physiology*

472 **MULLEN, R.K., and R.M. CHEW. 1973. Estimating the energy metabolism of free-living *Perognathus formosus*: a comparison of direct and indirect methods. Ecology 54:633:637.**

The results of an energy metabolism study of free-living Perognathus formosus, performed with the $D_2{}^{18}0$ method, are compared with data derived from metabolism chamber studies of the same species. Adding an activity correction factor to the metabolism chamber data results in oxygen consumption values essentially no different from those obtained from freeliving *P. formosus*. This agreement was not unexpected, since the two methods share a large common component, i.e., the energy expended for thermoregulation. The agreement was partly fortuitous, however, in that *P. formosus* happens to behave similarly in nature and in the laboratory. Other species do not so behave. Thus, if prior knowledge is lacking concerning the metabolic behavior of a species in its natural environment, any indirect method of estimating that behavior would have to be validated by a direct method. (Authors) *Keywords:* mammal*, physiology*

473 **MUMA, M.H. 1962. The arachnid order Solpugida in the United States, Supplement 1. Amer. Mus. Novitates 2091:1-44**.

Twenty-one new spp. and new genus, *Horribates*, (type sp. *H. spinigerus*) are described. The allotypes of 4 previously known spp. are described. New distribution records and several new or expanded keys to males are included. (Author) *Keywords:* invertebrate*, ecology/ecosystem*, taxonomy*

474 **MUMA, M.H. 1963. Solpugida of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 3(2), 13 pp.**

As part of the ecological study of the Nevada Test Site, nearly 1,000 specimens of solpugids were collected and identified as representing 28 species. Eight new species are described. A study is presented of the seasonal distribution and relative abundance of the sexes of 12 common species. Systematic collection data furnished ecological information about these species. (BBM) *Keywords:* invertebrate*, ecology/ecosystem*, taxonomy*

475 **MYLES, T.G., and M.M. HOOTEN. 2000. Evaluation of the Occurrence of Termite Species and Potential Termite Burrowing Depths in the Area of the Nevada Test Site: Present Day and for the Next 10,000 Years. Neptune and Company, Inc., Document Number 05100-01.**

This report reviews available literature on termites and on the ecology of the Nevada Test Site to produce a list of those termites which might be found in the area of the NTS. A table is presented along with a qualitative assessment of each termite species' probable occurrence, as well as the habitats they will likely be found in. The majority of foraging is very likely within the top 10 to 20 cm of soil for all species, and even at or above the soil surface for *Heterotermes*, *Reticulitermes*, *Gnathamitermes* and *Bolitotermes*. *Paraneotermes* and *Amitermes* tend to forage a bit lower, concentrating on the undersurfaces of buried wood and roots. A table is presented giving the likely percentiles associated with observing termites at various depths in the area of the Greater Confinement Disposal boreholes on Frenchman Flat. The probability of observing termites below 13 meters, even under cooler and somewhat wetter conditions over the next 10,000 years, is essentially zero. (CAW) *Keywords*: invertebrate*, ecology/ecosystem*

476 **NAGY, K.A. and P.A. MEDICA. 1977. Seasonal Water and Energy Relations of Free-living Desert Tortoises in Nevada: A Preliminary Report. In: The Desert Tortoise Council Proceedings of 1977 Symposium, pp. 152-157. Desert Tortoise Council, Inc., Long Beach, CA.**

A year-round study of water and energy balance in desert tortoises is being done in Rock Valley, Nevada Test site. Water fluxes and rates of CO_2 production are measured in filed animals using the doubly-labeled water method. Some preliminary results are presented here. Tortoises became active about the beginning of April 1976, and gained weight during spring while eating approximately 3-4% of their body mass in succulent annual plants each day. When annual plants began dying and drying out in late May, tortoises continued feeding on fry vegetation for a while, but surface activity declined into summer, as the animals spent progressively more time in burrows. From spring to summer, water influx rates dropped from about 25 to 5 ml $(kg.day)^{-1}$ and metabolic rates declined form about 0.15 to 0.08 ml CO_2 $(g.h)^{-1}$. Tortoises were dehydrating slowly in summer, judging by their declining body masses and the increasing osmotic pressure of their plasma (from approx. 290 to 360 mosM) and bladder urine (from approx. 180 to 330 mosM). With the advent of several thundershowers in late July, many tortoises quickly emerged and drank rainwater before it soaked into the ground. Some animals apparently did not drink during this period. Subsequent showers in September induced germination and growth of winter annuals during the fall. Tortoises fed on these plants and gained weight through October. Nearly all animals had entered deep winter burrows by mid-November. (Authors) *Keywords:* desert tortoise*, climate*, physiology*

477 **NAGY, K.A., and P.A. MEDICA. 1985. Altered Energy Metabolism in an Irradiated Population of Lizards at the Nevada Test Site. Radiation Research 103(1):98-104.**

Field metabolic rates (via doubly labeled water), body compartmentalization of energy stores, and energy assimilation efficiencies were measured to assess all avenues of energy utilization in *Uta stansburiana* living in a low-level gamma irradiated plot in Rock-Valley, Nevada. Comparison of energy budgets for radiation-sterilized females with those of nonirradiated control lizards revealed several substantial differences. Sterile females were heavier, mainly because they had extraordinarily large energy (fat) storage depots. Sterile females had much lower rates of energy expenditure via respiration and lower rates of energy intake by feeding. These differences are interpreted as indirect responses to radiation induced sterility. Gastrointestinal tract function in sterile females was normal. There is little evidence of direct radiation effects on physiological functions other than reproduction. (Authors) *Keywords:* reptile*, physiology*, radiation*

478 **NAGY, K.A., and P.A. MEDICA. 1986. Physiological Ecology of Desert Tortoises in Southern Nevada. Herpetologica 42(1):73-92.**

Seasonal changes in water balance, energetics, food consumption, daily behavior, diet, osmoregulation and body mass were measured using doubly labeled water, radiotelemeters, and field behavior observations of tortoises (*Gopherus agassizii*) through a year (1976-1977) in Rock Valley, Nevada. Aboveground activity extended over the warm seasons (between March and November), and tortoises hibernated in burrows through winter. In spring, tortoises were active for about 3 h every fourth day. Some drank rainwater and they all gained weight while eating succulent annual plants, which provided excess water and potassium that were stored in the urinary bladder, but energy intake was less than required to meet energy expenses via respiration, and body solids declined. As food plants dried in late spring, tortoises eventually achieved positive energy balance while eating grasses, but body masses declined due to negative water balance. Bladder urine became isosmotic with blood plasma, and both became more concentrated. As the summer drought continued, feeding diminished and tortoises spent progressively more time estivating in burrows. Thundershowers in July triggered emergence from estivation, and tortoises drank much rainwater, voided concentrated urine, accumulated dilute urine, restored normal plasma osmotic concentration, resumed feeding on the still-dry grasses and forbs, and accumulated much surplus energy. However, body masses declined during this time due to negative water balance, and osmotic concentrations in bladder urine increased. More rain in September again relieved this osmotic stress as tortoises drank, urinated, and stored dilute urine. Energy balance remained strongly positive until tortoises began feeding on the succulent new sprouts of annual plants that germinated in late September, and the tortoises returned to a spring-like physiological situation through mid-November when hibernation began. Tortoises apparently relinquish maintenance of internal homeostasis on a daily basis during most of the year, while tolerating large imbalances in their water, energy and salt budgets. This ability enables them to exploit resources that are only available periodically, while balancing their water and salt budgets on an annual basis and showing an energetic profit. The environmental properties of rainfall (beneficial to tortoises) and dietary potassium content (deleterious) appear to have major effects on the health of these impressive reptiles. (Authors) *Keywords:* desert tortoise*, climate*, physiology*

479 **NASH, T.H., S. WHITE, and J.M. NASH. 1974. Composition and biomass contribution of lichen and moss communities in the hot desert ecosystems. US/IBP Desert Biome Res. Memo. 74-19. Utah State University, Logan, UT, 7 pp.**

The general objective of this study was to determine the relative abundance of lichens and mosses at each of the southern desert validation sites. At each site, sampling was conducted over bajada, north slope and south slope locations. Altogether, 61 lichen species and 18 moss species were found. The largest number of lichens was 47 at Jornada's north slope; the largest number of mosses, 14 at Silverbell's bajada location. Lichen species numbers and abundance, as determined by cover or biomass, always exceeded moss species numbers and abundance. On the bajada portion of the validation sites, lichen cover was quite low: 0.012% at Rock valley, 0.041% at Silverbell and 0.0031% at Jornada. On the bajada sites moss cover was zero at Rock Valley and Jornada and was 0.020% at Silverbell. Species numbers and abundance for both lichens and mosses were greater on north slopes than south slopes. Lichen cover ranged up to 8.1% on the north slope at Jornada; moss cover, up to 0.27% on the north slope at Silverbell. Lichen biomass ranged from 0.088 g/m^2 on the Rock Valley bajada location to 38.281 g/m^2 on the Jornada north slope. Moss biomass ranged from zero at several locations to 0.534 g/m^2 on the Silverbell bajada. Lichens containing blue-green algae covered from 0.1 to 6.0 m^2/ha. Lichens, especially those containing blue-green algae, might have greater abundance on less disturbed bajada locations. The greater abundance of lichens on the north slopes is consistent with data from the literature, which demonstrates that desert lichens are photosynthetically adapted to cool temperatures. (Authors) *Keywords:* IBP*, microbiota*, ecology/ecosystem*

480 **NEEL, J.W., and K.H. LARSON. 1963. Biological availability of Strontium-90 to small native animals in fallout patterns from the Nevada Test Site. In: (Schultz, V., and A.W. Klement, Jr., Eds.) *Radioecology*, Proceedings of the First National Symposium on Radioecology, pp. 45-49.**

The levels of Sr-90 soil contamination originating from Nevada Test Site activities and the Sr-90 bone levels of native jack rabbits and, in some cases, kangaroo rats, were determined in areas at different distances from the test site. Detailed studies showed Sr-90 to be persistent in the surface soil over a period of one year, and other observations indicated persistence for at least several years. Jack rabbits collected in 1958, one year after contamination by the fallout from the Plumbbob Series in an area 99 miles from ground zero had Sr-90 levels averaging 19.4 Sr units at all ages. A similar collection in 1961 revealed a much reduced level of Sr-90 in the population (10.0 Sr units average) with the few higher values restricted to the older animals. It is postulated that the biological availability of Sr-90 in fallout is at its maximum at an early time after contamination; at later time the biological availability tends to be reduced by natural mechanisms in the environment. (Authors) *Keywords:* radionuclide inventory*, mammal*, radiation*

481 **NELSON, J.F., and R.M. CHEW. 1977. Factors Affecting Seed Reserves in the Soil of a Mojave Desert Ecosystem, Rock Valley, Nye County, Nevada. American Midland Naturalist: 97(2):300-320.**

During 1972, a second year of low herb production, there was a significant variation of seed reserves in the upper 2 cm of soil, with a doubling from February to June and a density-independent halving by October. In October 1972 there were 8×10^6 seeds/ha (5.3 kg/ha)/ After very high herb production in the spring, seed densities in October 1973 were 10-16 times greater under shrubs and 23-27 times greater in exposed areas (max 187.5×10^6 seeds/ha, 84.3 kg/ha). The increase was principally by the winter annual grass, *Festuca octoflora*. In 1972, when there was a small difference in rodent density between two plots (0..8:1.0), there was no effect of rodents on seed density. In 1973, when there was a 1:17.8 ratio of rodent densities, there was a significant effect on seeds, under shrubs. Then from October 1973 to October 1974, seed reserves in exposed areas between shrub decreased by 20% in the plot with few rodents, and by 40% in the plot with many rodents. Eating of seeds by rodents accounted for 30 t o 80% of the seed reserve decreases observed. Germination losses were no more than 25%. There is slight evidence that pocket mice selectively decrease abundance of the heavier species of seeds. Seed density was at least fie times greater under shrubs than in exposed areas; density was significantly correlated with the size of shrub canopy. There was also a significant effect of the species of shrub on the density of seeds. During years of low production, under-shrub areas are a refuge for herb seed production, and in such years shrub seeds form a larger portion of the seed crop and new reserves. The difference in response of shrubs and herbs to weather increases the stability of seed reserves. In May 1973 the number of herbs per 100 seeds in the previous October was 16.8 under shrubs and 43.6 in exposed areas; this implies a minimum germination of 24% of seeds over the whole habitat. It takes an exceptional coincidence of events, even in deserts, to cause a severe depletion of seed reserves. (Authors) *Keywords:* annual plants*, perennial plants*, mammal*, ecology/ecosystem*, nutrition/diet*

482 **NILES, W.E., P.J. LEARY, J. HOLLAND, and F.H. LANDAU. 1994. A Floristic Survey of Yucca Mountain and Vicinity, Nye County, Nevada. Contract No. DE-FCOS-90NV10872. U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 65.**

A survey of the vascular flora of Yucca Mountain and vicinity, Nye County, Nevada, was conducted from March to June 1994. An annotated checklist of recorded taxa was compiled. Voucher plant specimens were collected and accessioned into the Herbarium at the University of Nevada, Las Vegas. Collection data accompanying these specimens were entered into that herbarium's electronic data base. Combined results from this survey and the works of other investigators reveal the presence of a total of 325 specific and intraspecific taxa within the area, these allocated to 162 genera and 53 families. Owing to drought conditions prevalent throughout the area, the annual floristic component was largely absent during the period of study, and it is likely much under-represented in the tabulation of results. No taxon currently listed as threatened or endangered under the Endangered Species Act was encountered during this study. Several candidate species for listing under this Act were present, and distributional data for these were recorded. No change in the status of these candidate species is recommended as the result of this survey. (Authors) *Keywords:* YMSCO*, sensitive plants*, vegetation*, taxonomy*

483 **NILES, W.E., P.J. LEARY, J. HOLLAND, and F.H. LANDAU. 1995. A Floristic Survey of Yucca Mountain and Vicinity, Nye County, Nevada. Contract No. DE-FC0S-90NV10872. U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 51.**

A survey of the vascular flora of Yucca Mountain and vicinity, Nye County, Nevada, was conducted from March to June 1994, and from March to October 1995. An annotated checklist of recorded taxa was compiled. Voucher plant specimens were collected and accessioned into the Herbarium at the University of Nevada, Las Vegas. Collection data accompanying these specimens were entered into that herbarium's electronic data base. Combined results from this survey and the works of other investigators reveal the presence of a total of 375 specific and intraspecific taxa within the area, these allocated to 179 genera and 54 families. No taxon currently listed as threatened or endangered under the Endangered Species Act was encountered during this study. Several candidate species for listing under this Act were present, and distributional data for these were recorded. No change in the status of these candidate species is recommended as the result of this study. (Authors) *Keywords:* YMSCO*, sensitive plants*, vegetation*, taxonomy*

484 **NISHITA, H., and R.M. HAUG. 1973. Distribution of different forms of nitrogen in some desert soils. Soil Science 116:51-58.**

The distribution of different forms of N in desert soils collected at Nevada Test Site, USA, was examined. Soil profiles were sampled in 7.6-cm increments to various depths of which the maximum was 91.4 cm. Among the soil profiles examined, the different forms of N in the surface layer (0.0-7.6 cm) was always $N0_2^-$ -N (not detectable) <extractable NH_4^+ -N <$N0_3^-$ -N <fixed NH_4^+ -N<organic N. In the sublayers, some variations from this order of N forms occurred in that the extractable NH_4^+ -N was greater than $N0_3^-$ -N with the presence of trace amount of $N0_2^-$-N and/or the fixed NH_4^+ -N was greater than organic N. The amount of total N was the greatest in the surface layer and usually decreased very sharply in the 2nd layer (7.6-15.2 cm). Below the 2nd layer, the total -N contents generally varied slightly. In the surface layers, the total N was always accounted for primarily by organic N. Depending on the soil and the profile layer, the concentration of the total extractable inorganic N ranged 0.0004 - 0.00586% by weight of oven-dry soil. Expressed as percentage of total N, the range was 0.33 - 16.17. The amount of fixed NH_4^+ -N varied somewhat with different soils, but within any given soil profile, it generally varied slightly. The fixed NH_4^+ -N in the profiles collected in different areas and under different plant species ranged 0.0028 - 0.0079% by weight. Expressed as percentage of total N, the range was 3.4 - 74.4. The exchangeable K concentration under the plant was 41 - 240% greater than in the bare soil. The higher exchangeable K plus the higher organic matter content was considered to cause the lower $NH4^+$ -N fixation under the plant compared to its fixation in the bare soil. (EMD) *Keywords:* soil property*, vegetation*, nutrition/diet*

485 **NISHITA, H., and R.M. HAUG. 1981. Environmental Effects of Solar Thermal Power Systems - Environmental Effects of Heat Transfer and Storage Fluids Plant Toxicity and Movement in Soils. UCLA 12-1301, Laboratory of Biomedical and Environmental Sciences University of California, Los Angeles, CA, 40 pp.**

Field experiments on heat transfer and storage oils (Therminol 66, Caloria HT43, and Dow 200) were conducted in a desert environment at Nevada Test Site. The environmental conditions of the experiments were recorded by monitoring the rainfall, soil moisture tension, and air and soil temperatures. The downward movement of the oils in the soil profile was measured in two ways. In the plastic boxes, the downward movement of Therminol 66 was 6.3 cm during the experimental period of 281 days. The movement of Dow 200 in plastic boxes was 3.8 cm in 281 days. In the bare-soil plots, Therminol 66 moved to a 20.6-cm depth in 559 days. The movement of Caloria HT43 was to 18.7-cm depth in 336 days. For a comparable time period, the movement was Caloria HT43 > Therminol 66 > Dow 200. The movement in the bare-soil plots was appreciably greater than in plastic boxes. The probable causes of this difference were discussed. The deleterious effect of the oils on native plants was Dow 200 > Caloria HT43 > Therminol 66. The deleterious effect on plants depended on the stage of growth at which they were contaminated. *Ambrosia dumosa* contaminated in its dormant stage was less susceptible to injury than when it was contaminated in its green, leafed stage. (Authors) *Keywords:* soil property*, climate*, perturbations*, vegetation*

486 **NISHITA, H., and W.A. RHOADS. 1970. Ecological and environmental effects from local fallout from Schooner.   1. Soil thermoluminescence in relation to radiation exposure under field conditions. USAEC Report PNE-526, 21 pp.**

A study was conducted to determine whether or not soil thermoluminescence could be related to radiation exposure in the field under conditions of actual nuclear detonation. The correlation coefficients between TLD-100 LiF dosimeter determinations and soil thermoluminescence for noncalcareous and slightly calcareous soils were 0.93 and 0.89, respectively. These results suggest that soils might be used to estimate the radiation exposure received by a given area. With highly calcareous soil studied, the correlation coefficient (0.78) was poorer, indicating the lower suitability of this type of soil. Since soils exhibit variable amounts of "natural thermoluminescence;" pre-irradiation soil sample collection appeared to be necessary. This preirradiation sample might then be used to determine the amount of "natural" thermoluminescence and the "equivalent" exposure level by irradiating it with a known radiation source. The applicability of these procedures, however, remains to be tested. (Authors) *Keywords:* radionuclide inventory*, methods*, radiation*

487 **NISHITA, H., E.M. ROMNEY, and K.H. LARSON. 1965. Uptake of radioactive fission products by plants. In: (Fowler, E.B., Ed.) *Radioactive Fallout, Soils, Plants, Foods, Man*, pp. 55-81.**

Root uptake largely depends upon the solubility of fallout debris, the chemical reactions of individual radionuclides in soils, and the absorptive power of radionuclides by plants. The relative order of magnitude of plant uptake of fission products and plutonium appeared to be Sr-89, Sr-90 >> I-131 > Ba-140 > Cs-137, Ru-106 > Ce-144, Y-91, Pm-147, Zr-Nb-95 > Pu-239. Although the relative order of magnitude varied little, the absolute magnitude of uptake may be varied by certain soil management practices such as cultivation, fertilization and organic matter application. Aside from differential uptake, there was differential distribution of absorbed radionuclides among different plant parts. The soilplant step greatly reduces the amount of radionuclides transferred along the food chain to man. (HP) *Keywords*: vegetation*, nutrition/diet*, radiation*

488 **NISHITA, H., A. WALLACE, and E.M. ROMNEY. 1978. Radionuclide Uptake by Plants. UCLA 12-1158, CIC 0083204, University of California, Los Angeles, 90 pp.**

Natural radionuclides are always present in the environment and, together with those made by man in the past thirty or more years, differentially move through geochemical and biological cycles. The general principles governing the uptake, transport, and redistribution in plants of radionuclides are reviewed. Also plant uptake of selected radioisotopes of U, Ra, Th, Sr, I, Cs. Tc, Np, Pu. Am, and Cm are discussed in same detail. These isotopes were selected because of their potential usefulness or harmfulness to man in nuclear power generation and in other contexts. (Authors) *Keywords:* vegetation*, nutrition/diet*, radiation*

489 **NISHITA, H., R.H. MOORE, R.J. BECKMAN, and M. HAMILTON. 1975. Decay characteristics of soil thermoluminescence. Soil Science 119:259-268.**

Thermoluminescent decay of five different soils were examined after exposure to Co-60 photons or a neutron flux. In general, the shape of decay curves were similar: The most rapid decay occurred within 24-hr postirradiation, after which an apparent isothermal equilibrium state was approached. Curves were fitted to the decay data by the use of a computer program which obtains a weighted least squares fit of a function to the data by means of stepwise Gauss-Newton iterations on the parameters. Results indicated that the thermoluminescent decay curves of soils were hyberbolic in form. (Authors) (TPO) *Keywords:* radionuclide inventory*, radiation*

490 **NOWAK, R.S., J. COLEMAN, J. SEEMANN, and S. SMITH. 1999. Global change biology of deserts: Field studies by the Nevada Global Environmental Change Program. US DOE Joint Science Team Meeting, June 2-4, 1999, Indianapolis, IN.**

The Nevada Global Environmental Change (NevGEC) Program of the University of Nevada System has established two field research sites for conducting long-term studies of how global changes affect the Mojave Desert ecosystem. One site, the Nevada Desert FACE (Free Air CO_2 Enrichment) Facility (NDFF), focuses on the effects of elevated atmospheric CO_2. The second, a long-term desert ecological research site (LDER), focuses on nitrogen deposition, increased precipitation, and land-surface disturbance. Both studies, which are located on the U. S. DOE Nevada Test Site (NTS), are complementary to each other and are supported by experiments in controlled-environment facilities of the NevGEC Program. This combination of field research infrastructure associated with the NDFF and LDER sites, an extensive historical data set, and unparalleled security arrangements at the NTS make this an ideal site for conducting long-term research on the ecology of the Mojave Desert. This research enables us to: (1) investigate how global change may impact important ecosystem processes in the region; (2) investigate important ecological feedbacks between elevated CO_2 and other global environmental changes; and (3) begin focusing on important applied issues such as the desertification process and on the potential for global change to enhance revegetation efforts and the reclamation of disturbed desert lands. (Authors) *Keywords:* FACE*, perturbations*, vegetation*, ecology/ecosystem*, revegetation*

491 **NOWAK, R.S., J.R. SEEMANN, J.S. COLEMAN, and S.D. SMITH. 2000. Responses of desert vegetation to elevated atmospheric CO_2: The Nevada Desert FACE Facility. FACE 2000 Conference, June 27-30, 2000, Tsukuba, Japan.**

Conceptual models predict that desert ecosystems will be the most responsive to increased atmospheric CO_2 because the strong response of plant water-use efficiency to elevated CO_2 alleviates water limitations to primary production. The Mojave Desert is the most arid desert in North America and is strongly limited by water and nitrogen resources. Hence, the Nevada Desert FACE Facility (NDFF) was established to examine responses of desert vegetation to ambient (360 µmol mol^{-1}) and elevated (550 µmol mol^{-1}) CO_2 at leaf, whole plant, and ecosystem levels. The NDFF has operated 24 hours per day, 365 days per year since April 1997. Productivity of perennial vegetation was doubled by elevated CO_2, but only in a high rainfall year. Biomass production and seed rain of an invasive annual grass was increased much more than that of several species of native annuals by elevated CO_2 in a wet year, and to such an extent that elevated CO_2 could dramatically enhance the dominance of this exotic species. Photosynthesis of perennial and annual C_3 species was enhanced by elevated CO_2 by up to 50% under relatively wet conditions, but no effects occurred in a C_4 grass. Photosynthetic down-regulation was pronounced in wet seasons, but not in dry. A general pattern of reduced stomatal conductance under elevated CO_2 occurred during wet but not dry seasons, but the extent and timing of the reduction varied among species. Sap flow data indicate reduced canopy-level transpiration for the leafless shrub *Ephedra*, but not for the evergreen shrub *Larrea*. However in contrast to the leaf level measurements, canopy stomatal conductance was either unchanged or increased under elevated CO_2. Soil respiration integrated over a 24-hour period tended to be greater under elevated CO_2. Soil moisture for the top 0.5 m of soil and minirhizotron measurements of fine root length in the top 1 m of soil indicate little differences under elevated CO_2. Seedling survival for the 2 dominant shrubs, *Larrea* and

Ambrosia, were significantly higher under elevated CO_2. (Authors) *Keywords:* FACE*, climate*, soil property*, perturbations*, invasive species*, annual plants*, perennial plants*, physiology*, ecology/ecosystem*, life history*

492 NOWAK, R.S., L. DEFALCO, P. VIVIN, C. YODER, and C. BIGGART. 1999. Effects of elevated CO_2 on root systems of Mojave Desert vegetation. US DOE Joint Science Team Meeting, June 2-4, 1999, Indianapolis, IN.

Results from *in situ* minirhizotron tubes at the Nevada Desert FACE Facility during the first year after a step change in CO_2 concentration are presented. Root images were collected from the top 1 m of soil for the two dominant shrubs, *Ambrosia dumosa* and *Larrea tridentata*, as well as from transects representative of the plant community. During the late fall and early winter, the evergreen species *Larrea* produced greater fine root length in the upper 0.5 m of soil under elevated CO_2 than under ambient CO_2. However, new root production during the spring was large enough under ambient conditions such that total fine root length for the entire soil profile did not differ between species. For the deciduous species *Ambrosia* as well as for the plant community in general, wintertime root production was similar between CO_2 treatments, but production of roots in the spring was slightly lower under elevated CO_2. In general, the depth distribution of root length under ambient CO_2 was unimodal, with the greatest concentration at 0.2-0.4 m. In contrast, the depth distribution in the elevated CO_2 treatment started with a shallower mode of 0-0.2 m and then developed a distinct bimodality in April and May, with peak root concentrations at 0-0.2 m and 0.4-0.6 m depth. When averaged over all tubes from *Larrea*, *Ambrosia*, and the community transects, the proportion of minirhizotron frames that contained roots was not consistently different between CO_2 treatments. This study also provides the first data on the root growth and physiological responses of 3 important Mojave Desert grasses: the C_3 perennial *Achnatherum hymenoides*, the C_4 perennial *Pleuraphis rigida*, and the C_3 annual *Bromus madritensis* ssp. *rubens* to long-term CO_2 enrichment. Although aboveground productivity was increased in both C_3 grasses, root biomass was only increased in the C_3 perennial grass. Little evidence for up-regulation in root physiology or nutrient uptake in response to CO_2 was observed in any of the 3 grasses. (Authors) *Keywords:* FACE*, perturbations*, invasive species*, annual plants*, perennial plants*, physiology*

493 NOWAK, R.S., D.N. JORDAN, L.A. DEFALCO, J.S. COLEMAN, J.R. SEEMANN, and S.D. SMITH. 2000. Effects of elevated CO_2 on leaf conductance and temperature for three desert perennials at the Nevada Desert FACE Facility. FACE 2000 Conference, June 27-30, 2000, Tsukuba, Japan.

One of the most commonly observed responses of plants to increased atmospheric CO_2 has been decreased leaf conductance. As a consequence of this decreased conductance, leaf temperature has been predicted to increase under elevated CO_2. To test these predictions in an intact desert ecosystem, diurnal patterns in leaf conductance and temperature for 3 Mojave Desert perennials, *Larrea tridentata* (creosotebush), *Achnatherum hymenoides* (Indian rice grass), and *Pleuraphis rigida* (galleta grass), were measured under ambient (360 µmol mol') and elevated (550 µmol mol-1) atmospheric CO_2 at the Nevada Desert FACE Facility. Measurements were made during the last part of the spring and into the summer after the initiation of CO_2 fumigation (*Larrea* only) and during the next growing season (all 3 species), which was characterized by above-average precipitation associated with an intensive El Niño event. For the C_3 evergreen shrub *Larrea*, leaf conductance was not significantly different between CO_2 treatments during extreme drought periods, but conductance was consistently lower under elevated CO_2 during the relatively wet El Niño year, especially during mid-morning. A similar response was found for the C_4 bunchgrass *Pleuraphis*. For these 2 species, leaf conductance for plants growing under elevated CO_2 essentially did not vary diurnally, whereas conductance for plants growing under ambient conditions had a midmorning peak in conductance followed by mid-afternoon stomatal closure that is typically observed in desert plants. For the C_3 bunchgrass *Achnatherum*, conductance also varied diurnally. However, both morning and afternoon conductance for plants growing under elevated CO_2 were significantly lower during the first part of the growing season, but not during the latter part of the growing season. Differences in leaf temperature under elevated atmospheric CO_2 did not occur for these desert plants, probably because leaf temperature of microphyllous species tend to be closely coupled to air temperature. (Authors) *Keywords:* FACE*, climate*, perturbations*, annual plants*, perennial plants*, physiology*

494 **NOWAK, R.S., L.A. DEFALCO, C.S. WILCOX, D.N. JORDAN, J.S. COLEMAN, J.R. SEEMANN, and S.D. SMITH. 2000. Effects of elevated CO_2 on leaf conductance and temperature for three desert perennials at the Nevada Desert FACE Facility. New Phytologist (In press).**

A common response of plants to elevated atmospheric CO_2 concentration ($[CO_2]$) is decreased leaf conductance. As a consequence of decreased conductance, leaf temperature is predicted to increase under elevated $[CO_2]$. To test these predictions, diurnal patterns in leaf conductance and temperature were measured for three desert perennials, the C_3 shrub *Larrea tridentata*, the C_3 tussock grass *Achnatherum hymenoides*, and the C_4 tussock grass *Pleuraphis rigida* at the Nevada Desert FACE Facility. Measurements began in 1997 after a step change in atmospheric $[CO_2]$ to ~550 µmol mol-1 and continued through both a wet (1998) and a dry (1999) year. All three species exhibited decreased leaf conductance under elevated $[CO_2]$, although reductions were not necessarily uniform during the day or among years. *Pleuraphis* had the greatest overall reduction (35%), followed by *Achnatherum* (20%) and *Larrea* (13%). Decreased conductance occurred throughout the day for *Pleuraphis*, during mid-afternoon and occasionally mid-morning for *Achnatherum*, and only during mid-morning for *Larrea*. Both C_3 species had smaller $[CO_2]$ effects during dry periods than wet. Although dry/wet inferences are difficult to make for the C_4 species because of a small number of sampling dates, our results are consistent with other studies that show little interaction between elevated $[CO_2]$ and drought stress for C_4 grasses. Despite reductions in conductance, leaf temperature did not differ significantly between plants growing in elevated and ambient $[CO_2]$ plots for any of the species. Finally, comparisons of blower-control and non-ring plots indicated that the FACE apparatus did not confound our results for leaf conductance and temperature. (Authors) *Keywords:* FACE*, climate*, perturbations*, perennial plants*, physiology*

495 **O'FARRELL, T.P. 1984. Populations of Small Mammals Inhabiting Sites 22 to 32 Years after Nuclear Events. Presented at: Joint International Meeting of the Australian and the American Society of Mammalogists, Sydney, Australia, 9 Jul 1984. EGG-10282-2046, CONF-840770-1, EG&G Energy Measurement, Inc., Las Vegas, NV, 20 pp.**

Objectives were to: (1) gather information to test whether nuclear events had long-term impacts on populations of indigenous mammals, (2) determine the exposure dose to small mammals living proximate to ground zeros (GZ) and in other contaminated areas, (3) document residency patterns of small mammals inhabiting various radioactivity levels so that adequate tissue samples could be obtained for radioanalyses from animals resident to the area, and (4) examine transfer coefficients from soils and food items to mammalian tissues. These tasks were undertaken to provide comparative information in two types of nuclear event sites: (1) atmospheric nuclear event sites subjected initially to intense ionizing and thermal radiation, blast damage, and to chronic exposure to low-level radioactivity; and (2) a cratering experiment in which a deep overburden containing radioactivity was deposited, along with ground motion and some blast damage but no intense thermal and ionizing radiation. Changes in species composition and relative abundance appear to be most clearly related to the alterations in vegetative structure and function. Little information was gathered to suggest that residual levels of ionizing radiation were casually linked to mammalian succession. No population information indicated effects that might be related to chronic radiation insult from either external or internal sources. Based on the results of this study, one would predict that the same alterations in mammalian populations would have been observed at +22 to +32 years if the soils and vegetation had been similarly destroyed or damaged by thermal, mechanical, or physical means that did not involve nuclear devices. 10 references, 3 figures, 7 tables. (Author) *Keywords:* perturbations*, vegetation*, mammal*, radiation*

496 **O'FARRELL, T.P., and E. COLLINS. 1983. 1982 Biotic Studies of Yucca Mountain, Nevada Test Site, Nye County, Nevada. EG&G Energy Measurements Report No. EGG 10282-2004. Goleta, CA.**

In 1981 an extensive literature review was conducted to determine the current state of knowledge about the ecological characteristics of the Yucca Mountain study area and to identify what site-specific information was lacking. Based on the findings of the review a field study was initiated in 1982 to gather site-specific information on the ecological characteristics of the project area. The biota observed were representative of either the Mojave or Transition deserts that are widely distributed in southern Nevada and the arid Southwest. No unusual vegetation associations or assemblages of animals were observed. Based on observations of tracks and scats it was concluded that low numbers of both mule deer and feral burros used the area seasonally, and that neither species should be severely threatened by the proposed activities. The Mojave fishhook cactus and desert tortoise, both under consideration for federal protection as threatened species, were found to occur in the study area. The former was distributed in notable densities on the rocky ridgelines of Yucca

Mountain in areas that should not be greatly disturbed by site characterization or future repository activities. Evidence of desert tortoise was observed throughout the project area to elevations of 5,240 ft; however, relative densities were estimated to be low (less than 20 per square mile). Physical destruction of soils and native vegetation was determined to be the most significant negative effect associated with current and proposed characterization activities. Solution holes in exposed flat rock on ridgelines that served as passive collectors of precipitation and runoff were the only sources of free water observed. While these water supplies were not adequate to support riparian vegetation, there was evidence that they

served as an important ephemeral source of water for wildlife. (Authors) *Keywords:* YMSCO*, desert tortoise*, vegetation*, vertebrate*, sensitive animals*, sensitive plants*, ecology/ecosystem*

497 O'FARRELL, T.P., and E. COLLINS. 1984. 1983 Biotic Studies of Yucca Mountain, Nevada Test Site, Nye County, Nevada. EG&G Energy Measurements Report No. EGG 10282-2031. Goleta, CA.

A 27.5-square-mile portion of Yucca Mountain on and adjacent to the U.S. Department of Energy's Nevada Test Site, Nye County, Nevada, is being considered as a potential location for a national high-level radioactive waste repository. Preliminary geologic and environmental characterization studies have been supported and more extensive studies are planned. Goals of the biotic surveys were to identify species of concern, describe major floral and faunal associations, and assess possible impacts of characterization and operational activities. Floral associations observed were characteristic of either the Mojave or Transition deserts that are widely distributed in southern Nevada. Diversity, in terms of total number of perennial species represented, was higher in Transition Desert associations than in Mojave Desert associations. Canopy coverage of associations fell within the range of reported values, but tended to be more homogeneous than expected. Annual vegetation was found to be diverse only where the frequency of *Bromus rubens* was low. Ground cover of winter annuals, especially annual grasses, was observed to be very dense in 1983. The threat of range fires on Yucca Mountain was high because of the increased amount of dead litter and the decreased amount of bare ground. Significant variability was observed in the distribution and relative abundance of several small mammal species between 1982 and 1983. Deer mice and cactus mice, two species not trapped in 1982, were captured regularly in 1983. The deer mouse was the most ubiquitous and the fourth most abundant species captured. The long-tailed pocket mouse and Merriam's kangaroo rat continued to be the most abundant species captured, although the former was much less abundant at high elevations than in 1982. Total captures on all traplines were highest in April and August and lowest in June. Desert tortoise were found in low densities comparable with those observed in 1982. Evidence of recent activity, which included sighting of two live tortoises, was found in five areas on Yucca Mountain. Two of these areas have a high probability of sustaining significant impacts if a repository is constructed. No additional species of concern were identified other than those observed in 1982. Regeneration of aboveground shrub parts from root crowns was observed in areas damaged in 1982 by seismic testing with Vibroseis machines. These areas, which had been cleared to bare dirt by passage of the machines, also supported lush stands of winter annuals. (Authors) *Keywords:* YMSCO*, perturbations*, desert tortoise*, invasive species*, annual plants*, vegetation*, mammal*, ecology/ecosystem*

498 O'FARRELL, T.P., and L.A. EMERY. 1976. Ecology of the Nevada Test Site: A Narrative Summary and Annotated Bibliography. DOE/NVO-167. DOE Nevada Field Office, Las Vegas, NV, 349 pp.

This document contains a summary of the ecology of the Nevada Test Site developed through existing scientific publications. It includes an annotated bibliography of 333 citations pertaining to ecological research conducted on NTS, a list of ERDA/NSF Desert Biome Research Memoranda, lists of Nevada Test Site flora and fauna, a list of citations concerning the fate and effects of nuclear and non-nuclear disturbances on the environment, and a compilation of references used to develop the document. (Authors) *Keywords:* bibliography*, climate*, geology*, hydrology*, soil property*, radionuclide inventory*, vegetation*, microbiota*, invertebrate*, vertebrate*, ecology/ecosystem*, radiation*, taxonomy*

499 O'FARRELL, T.P., and M.L. SAULS. 1987. Impacts of Cleanup and Treatment (CAT) Trails on Relative Density of Small Mammals and Lizards. In: The Dynamics of Transuranics and Other Radionuclides in Natural Environments (Howard, W.A., and R.G. Fuller, Eds.). U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV. NVO-272, pp. 317-320.

The impacts of cleanup and treatment trials to test application of a vacuum device in Area 11, Nevada Test Site (NTS), were assessed to determine biological costs. Prior to the test, there was an average density of 300 small mammal burrows per hectare. Removal of all shrubs and 2-5 cm of surface soil resulted in complete elimination of small mammals from the test plots for two years. More lizards were observed in control versus treated plots after the test. If these CAT techniques were implemented on a large scale, there would be a significant biological cost in terms of loss of vertebrate populations. *Keywords:* NAEG*, perturbations*, perennial plants*, mammal*, reptile*

500 **O'FARRELL, T.P., and M.L. SAULS. 1987. Small Mammals Inhabiting Nuclear-Event Sites: Population Characteristics and Radionuclide Body Burden. In: The Dynamics of Transuranics and Other Radionuclides in Natural Environments (Howard, W.A., and R.G. Fuller, Eds.). U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV. NVO-272, pp. 279-304.**

Field studies were conducted between 1980 and 1983 to determine whether past nuclear events had significantly altered population parameters of indigenous small mammals, to measure exposure doses to animals living proximate to ground zeros (GZ) and in other contaminated areas, and to analyze the tissue distribution of radionuclides, especially transuranics, in resident mammals. PALANQUIN was an underground test that vented radioactive fallout over a large area of Pahute Mesa. In portions of the fallout field, initial radioactivity was sufficient to kill all shrubs, leaving a grassland; in other parts, exposures damaged some shrubs but the steppe associations survived. Fifteen years after the event there were no significant differences in species composition and relative abundance of small mammals trapped in shrub versus shrubless habitats. ^{90}Sr was the only fission product consistently found in tissues of *Peromyscus maniculatus* and *Perognathus parvus* collected at varying distances from GZ. ^{239}Pu and ^{241}Am were detectable in 22 percent of the tissues. Quantities (nCi/g ash) were 10^{-5} in carcasses, 10^{-3} in organs, and 10^{-3} in gastrointestinal tracts and contents. Concentrations did not differ between species, between shrub and shrubless plots, or with increasing distances from GZ. Naturally occurring radionuclides ^{226}Ra, ^{231}Pa, ^{232}Th, ^{235}U, and ^{238}U were also found in both species although ^{235}U was almost exclusively found, in 10^{-1} nCi concentrations, in *Peromyscus maniculatus*. SEDAN was a thermonuclear cratering experiment on Yucca Flat that deposited a large quantity of radioactive overburden on the existing soils and plants. Twenty years after the event, there was a significant change in species composition and a reduction in relative abundance of small mammals trapped in the area of greatest throw out within 1,000 m of GZ. There were no significant differences in number of individuals trapped at greater distances from GZ regardless of the presence or absence of shrubs, although some species showed clear preferences for habitats containing shrubs. *Dipodomys merriami* was the dominant kangaroo rat in areas once exclusively dominated by *Dipodomys microps*. *Perognathus parvus* was extirpated by the event, and no evidence of *Dipodomys ordii* present after the event, was obtained. Six atmospheric nuclear tests were conducted over the T2 triad. After 25-30 years, there was an inverse relationship between number of individual small mammals trapped and the distance from GZ, and a corresponding positive correlation between number of species and distances from GZ. The farthest plot still contained its original shrub cover, while the remaining sites were shrubless disclimaxes of some perennial grasses and weedy annual plants. Many of the changes in population characteristics may be causally linked to changes in the structure of the disturbed vegetation associations. However, circumstantial evidence suggests that exposure to chronic, low-level radiation, both externally and internally, may contribute to patterns of species diversity if radiosensitivity of the species is not equal. (Authors) *Keywords:* NAEG*, perturbations*, perennial plants*, mammal*, radiation*

501 **O'FARRELL, T.P., E. COLLINS, and M.L. SAULS. 1982. Description of Major Vegetation Associations and Their Potential Contribution to Range Fires Generated by LNG Combustion Tests on Frenchman Flat, Nevada Test Site, Nye County, Nevada. Lawrence Livermore National Laboratory, U.S. Department of Energy, Nevada Operations Office.**

Lawrence Livermore National Laboratory is planning to conduct tests at the Nevada Test Site on the physical and environmental effects of controlled spills of liquified natural gas. Large combustion tests may cause range fires that could threaten adjacent Air Force and Fish and Wildlife Service lands. The major objective of this study was to provide information necessary for assessing the potential for range fires in various native vegetation associations next to Frenchman Lake. Data on types and extent of vegetation associations were gathered during field surveys and after examination of aerial photographs. The six major vegetation associations described, within 7.7 km of the LNG site, and their areal dimensions, were: *Larrea*, 11,981 ha; *Atriplex*, 1,920 ha; *Lycium pallidum*, 1,894 ha; *Ephedra-Atriplex*, 358 ha; *Coleogyne*, 128 ha; and *Lycium shockleyi*, 102 ha. Range fire potential within the most widespread associations was relatively low because of the sparse density of potential fuel, 227 to 2,690 kg/ha, which consisted mainly of widely spaced shrubs having canopy coverage less than 19%. The most fire-prone association, *Coleogyne*, had a fuel density between 2,779 and 5,018 kg/ha and a canopy cover up to 50%, but it was restricted in area to a narrow band on the bajadas of the Ranger Mountains several Kilometers from the LNG site. Range fire potential would increase during years in which abundant precipitation simulated increased production of winter annual species. Existing U.S. Forest Service models used to make short-term predictions of range fire potential may be applicable to the NTS. Models to assess range fire conditions weeks or months in advance are not yet available because they have not been validated with long-term baseline information. Validation may be possible using existing DOE/OHER field data from the NTS. (Authors) *Keywords:* perturbations*, vegetation*, annual plants*, perennial plants*, ecology/ecosystem*

502 OLAFSON, J.H., and K.H. LARSON. 1963. Plutonium, its biology and environmental persistence. In: (Schultz, V., and A.W. Klement, Jr., Eds.) *Radioecology*, Proceedings of the First National Symposium on Radioecology, pp. 633-639.

A brief review is presented of the metabolism and distribution of plutonium in animal tissues, plants, food and the environment. Plutonium as an environmental contaminant does not appear to be a serious problem because of its biological and physical properties which do not favor high accumulation in the environment, plants, animals or man. Hasty conclusions should not be drawn since little can be predicted about future levels of accumulation. (KM) *Keywords:* vegetation*, vertebrate*, radiation*

503 OLAFSON, J.H., J.W. NEEL, C.J. SPIEGL, R.H. WILSON, F.G. LOWMEN, and K.H. LARSON. 1953. Preliminary study of off-site, airborne radioactive materials, Nevada proving grounds. I. Fallout originating from Snapper 6, 7, and 8 at distances of ten to fifty miles from ground zero. USAEC Report UCLA-243, 123 pp.

The operations of the intermediate zone fall-out program (10 to 50 miles) conducted in connection with Operation Snapper 6, 7, and 8 during May and June 1952 are reviewed. The maximum concentrations of airborne fission products in this area as determined by means of Hi-Volume samplers were 1.0 to 2.7 uc/m^3. Particle size distribution of the airborne material was determined by modified Casella Cascade impactors. Fall-out patterns were determined by gummed papers. Decay data are presented on a number of selected typical samples from each detonation. (WDM) *Keywords:* radionuclide inventory*

504 ORCUTT, J.A. 1982. Cleanup and Treatment (CAT) Test: A Land Area Decontamination Project Utilizing a Vacuum Method of Soil Removal. DOE/NV/00410-70. Reynolds Electrical & Engineering Co., Inc. Las Vegas, NV.

The Cleanup and Treatment (CAT) test was conducted over a 3-month period in the plutonium safety shot or "Plutonium Valley" portion of Area 11. Soil in Plutonium Valley is of the Aridisol Order. The surface 0-10 cm is a gravelly loam, and is strongly alkaline (pH 8.8). The alluvial soil was formed in material weathered from tuff, basalt, and limestone. Slight to moderate wind and water erosion is evident (Reference 1). A large truck-mounted vacuum unit, rather than conventional earthmoving equipment, was used as the primary soil collection unit. The CAT test served as an evaluation of the viability of a vacuum method of land area decontamination. Effectiveness of the vacuum method of soil removal was evaluated in relation to conventional earthmoving procedures, particularly in terms of volume reduction of removed soil achieved over conventional techniques. Radiological safety considerations associated with use of the vacuum unit were evaluated in relation to their impact on a full-scale land decontamination program. Environmental and operational impacts of devegetation with retention of root crowns or root systems were investigated. (Author) *Keywords:* perturbations*, radionuclide inventory*, vegetation*, methods*

505 OSTLER, W.K., and D.J. HANSEN. 2000. Biodiversity Analysis of Vegetation on the Nevada Test Site. DOE/NV/11718–423-ABS, 11th Wildland Shrub Symposium, Provo, UT, 6/13/2000 - 6/15/2000. Bechtel Nevada, Las Vegas, NV.

The Nevada Test Site (NTS), located in south-central Nevada, encompasses approximately 3,500 square kilometers and straddles two mayor North American deserts, Mojave and Great Basin. Transitional areas between the two desert types have been created by gradients in elevation, precipitation, temperature, and soils. From 1996 to 1998, more than 1,500 ecological landform units were sampled at the NTS for numerous biotic and abiotic parameters. The data provide a basis for spatial evaluations of biodiversity over landscape scales at the NTS. Biodiversity maps (species richness vs. species abundance) have been produced. Differences in biodiversity among ecoregions and vegetation alliances are presented. Spatial distribution maps of species' presence and abundance provide evidence of where transition zones occur and the resulting impact on biodiversity. The influences of abiotic factors, such as elevation, soil, and precipitation, on biodiversity are assessed. (Authors) *Keywords:* vegetation*, ecology/ecosystem*

506 OSTLER, W.K., and T.P. O'FARRELL. 1994. The Terrestrial Ecosystem Program for the Yucca Mountain Project. EGG 11265-1058, EG&G Energy Measurements, Las Vegas, NV.

This paper describes the various tasks and studies being conducted to monitor and mitigate the possible ecological impacts of Site Characterization Activities at Yucca Mountain. Site Characterization Activities include all field investigations conducted to evaluate Yucca Mountain as a possible site of a geologic repository for high level radioactive waste. This paper described the Environmental Field Activity Plan for Terrestrial Ecosystems which was issued by DOE in 1989 and updated in 1992. It consists of three major components: Activity Surveys, Desert Tortoise Studies, and Site Characterization Effects Studies. Also discussed are the Reclamation Program Plan, Reclamation Implementation Plan, and Reclamation Feasibility Plan. (CAW) *Keywords:* YMSCO*, perturbations*, desert tortoise*, vegetation*, vertebrate*, ecology/ecosystem*, revegetation*

507 OSTLER, W.K., D.J. HANSEN, D.C. ANDERSON, and D.B. HALL. 2000. Classification of Vegetation on the Nevada Test Site. DOE/NV/11718--477, Bechtel Nevada Ecological Services, Las Vegas, NV.

The Nevada Test Site (NTS) was used for nuclear testing from 1951 to 1992. Despite years of testing only about 7 percent of the 3,567 square kilometers (1,375 square miles) of the site has been disturbed (U.S. Department of Energy, 1996b). Although drastic changes to localized areas due to nuclear testing have occurred, biological resources over much of the NTS remain relatively pristine and undisturbed. Diversification in the mission of the NTS, as described in the recent programmatic NTS Environmental Impact Statement, has created a need to provide detailed information about vegetation for the purposes of National Environmental Policy Act compliance, ecosystem management, ecological monitoring, and resource management planning. Before resources can be effectively managed and preserved, they must first be identified and described. Vegetation classification and mapping are among the first steps in implementing ecosystem management on the NTS. Preparation of an accurate vegetation map and more detailed descriptions of vegetation and wildlife habitat are essential for ecosystem management for new projects or to support expanding existing projects on the NTS. Mapping of vegetation was initiated by first identifying landforms and delineating their boundaries from prints of aerial photographs (1:24000 scale) of the NTS and SPOT satellite imagery. Boundaries of landforms with similar physical and biological properties were then verified in the field and modified to delineate ecological landform units (ELUs). The intent was not to subjectively or arbitrarily classify the ELUs as a particular vegetation type or subtype, but rather to delineate all of the basic building blocks or areas that were relatively homogeneous and would respond similarly to management practices and allow computer clustering techniques classify the ELUs. Based on an iterative clustering process, 10 alliances and 20 associations were recognized as occurring on the NTS. Alliances and associations were named after the dominant tree or shrub species based on relative abundance and according to Federal Geographic Data Committee and Ecological Society of America conventions. Two major vegetation groups or ecoregions, Mojave Desert and Great Basin Desert, can be identified from this classification. Between these two deserts is a broad transition zone that often includes a mixture of species from either major ecoregion. Analysis of species diversity (richness or the number of species) of perennial trees and shrubs is presented. Species richness of woody species was greatest in the Great Basin Desert compared to associations in the Transition Zone and the Mojave Desert. Similar species diversity patterns were also observed for all combined perennial species on the NTS. Several appendices are presented that provide details of vegetation on the NTS, including lists of all species that have been recorded on the NTS and the vegetation alliances where they are commonly found, relative abundance and frequency values for species in vegetation alliances and associations, and species names and codes. (WKO) *Keywords:* geology*, soil property*, microbiota*, vegetation*, ecology/ecosystem*, taxonomy*

508 OSTLER, W.K., T.P. O'FARRELL, V.K. WINKEL, and B.W. SCHULTZ. 1991. Reclamation program for the Yucca Mountain Project. *Presented at*: American Nuclear Society (ANS) International High Level Radioactive Waste Management Conference, Las Vegas, NV, 28 Apr - 3 May 1991. EGG-10617-2074, CONF-910435-63, EG&G Energy Measurements, Inc., Las Vegas, NV, 19 pp.

The US Department of Energy (DOE) is required by law and other regulatory requirements to reclaim disturbances created by site characterization activities at Yucca Mountain. Because of the difficulty of reclaiming arid areas and the lack of site specific information on successful reclamation techniques and procedures, the DOE has developed a comprehensive reclamation program. The program consists of three phases: planning, operational and research. The planning phase is a continuing process that ensures that program policy, goals, tasks and responsibilities are clearly identified and linked. The operational phase uses best available knowledge to develop and implement reclamation plans that are site-specific for each disturbance. Reclamation activities start prior to any surface disturbance with a survey of each disturbance by trained scientists. The scientists survey the area for the presence of protected species or critical wildlife habitat. They also gather vegetation, landscape, soils and other environmental data that is used to assess the impact of the proposed disturbance. Recommendations can be made to either avoid areas or mitigate impacts. The operational phase includes interim reclamation to protect valuable resources and control erosion prior to final reclamation. Monitoring of reclaimed sites is conducted to correct problem areas and insure that reclamation objectives are achieved. The third phase of the reclamation program is designed to provide site-specific information on effective reclamation techniques through research and field demonstrations. 52 refs., 1 tab. (Authors) *Keywords:* YMSCO*, perturbations*, vegetation*, revegetation*

509 **PAGLIA, D.E. 1968. Hematopathologic surveys of kangaroo rats (*Dipodomys microps*) populating plutonium contaminated regions of the Nevada Test Site. Health Physics 15:493-498.**

Hematologic characteristics were assessed in 765 kangaroo rats (*Dipodomys microps*) indigenous to five Pu-239 contaminated regions and two control areas within the Nevada Test Site. Bone and lung specimens, gastrointestinal contents, and environmental air and soil samples from all but one of these populations were assayed for Pu-239 content. Gross pathologic changes appeared minimal and nonspecific. Mean platelet levels in two exposed groups were slightly lower than control values. One of these groups, for which Pu-239 data were unavailable, also exhibited lower mean levels of peripheral lymphocytes. While significant statistically, all blood-cell depressions were physiologically inconsequential. Statistical evaluations disclosed no-correlation between available Pu-239 burdens and any measured biological parameter. Reported values may serve additionally as useful baseline data in the event of resumption of atmospheric nuclear weapons testing or accidental venting of underground detonations. (Author) *Keywords*: mammal*, radiation*, physiology*

510 **PARAN, T.P. 1966. A new fur mite, *Lavoimyobia hughesi* n.g., n. sp. (Acarina: Myobiidae) from a North American rodent. Journal of Medical Entomology 3:172-178.**

A description is given of a myobiid, *Lavoimyobia hughesi* n.g., n.sp., taken from Merriam's Kangaroo Rat, *Dipodomys merriami* Mearns, in Nevada, U.S.A. The new myobiid is interesting in that it shows both advanced and primitive features, and appears to be the first myobiid to be described from Kangaroo Rats. (Author) *Keywords:* invertebrate*, mammal*, taxonomy*

511 **PATAKI, D.E., T.E. HUXMAN, D.N. JORDAN, S.F. ZITZER, J.S. COLEMAN, S.D. SMITH, R.S. NOWAK, and J.R. SEEMANN. 2000. Water use of two Mojave Desert shrubs under elevated CO_2. Global Change Biology 6:889-898.**

Plant responses to elevated atmospheric CO_2 have been characterized generally by stomatal closure and enhanced growth rates. These responses are being increasingly incorporated into global climate models that quantify interactions between the biosphere and atmosphere, altering climate predictions from simpler physically based models. However, current information on CO_2 responses has been gathered primarily from studies of crop and temperate forest species. In order to apply responses of vegetation to global predictions, CO_2 responses in other commonly occurring biomes must be studied. A Free Air CO_2 Enrichment (FACE) study is currently underway to examine plant responses to high CO_2 in a natural, undisturbed Mojave Desert ecosystem in Nevada, USA. Here we present findings from this study, and its companion glasshouse experiment, demonstrating that field-grown *Ephedra nevadensis* and glasshouse-grown *Larrea tridentata* responded to high CO_2 with reductions in the ratio of transpirational surface area to sapwood area (LSR) of 33% and 60%, respectively. Thus, leaf-specific hydraulic conductivity increased and stomatal conductance remained constant or was increased under elevated CO_2. Field-grown *Larrea* did not show a reduced LSR under high CO_2, and stomatal conductance was reduced in the high CO_2 treatment, although the effect was apparent only under conditions of unusually high soil moisture. Both findings suggest that the common paradigm of 20-50% reductions in stomatal conductance under high CO_2 may not be applicable to arid ecosystems under most conditions. (Authors) *Keywords:* FACE*, climate*, perturbations*, perennial plants*, physiology*

512 **PATTON, S.E., and L.R. ANSPAUGH. 1988. Basic Environmental Compliance and Monitoring Program (BECAMP) Year-End Summary Report FY 1987. UCAR-10244-87, Lawrence Livermore National Laboratory, Livermore, CA, 18 pp.**

The Basic Environmental Compliance and Monitoring Program (BECAMP) goals are to assess changes over time in the radiological and ecological conditions at the Nevada Test Site (NTS) and to provide information necessary for assessing NTS compliance with applicable environmental regulations. Five objectives were developed to meet the goals:1) maintain and enhance the knowledge of the radionuclide inventory and study the movement of surface contaminants on and around the NTS, 2) maintain and update human dose-assessment models for the NTS and its environs and periodically conduct field studies to test the predictions of the models, 3) maintain and update an understanding of the spatial distribution and changes over time of the flora and fauna on the NTS, 4) provide a major yearly thematic, peer-reviewed publication to address an important issue related to the potential environmental impacts of past, present, and future activities at the NTS, and 5) comply with applicable environmental regulations. This report provides a summary of the progress made and work completed on BECAMP milestones for fiscal year (FY) 1987. This document was prepared from year-end summary reports submitted by the principal investigators participating in BECAMP. Included in this document are a brief description of BECAMP, a summary of BECAMP accomplishments for FY 1987, summary reports of work completed toward FY 1987 milestones, a list of BECAMP participants for FY 1987, and a list of publications from BECAMP participants that relate to BECAMP efforts. (Authors) *Keywords:* radionuclide inventory*, vegetation*, vertebrate*, radiation*, ecology/ecosystem*

513 PATTON, S.E., and L.R. ANSPAUGH. 1988. Basic Environmental Compliance and Monitoring Program (BECAMP) FY 1988 Year-End Summary Report. UCAR-10244-88, Lawrence Livermore National Laboratory, Livermore, CA, 21 pp.

The Basic Environmental Compliance and Monitoring Program (BECAMP) FY 1988 Year-End Summary Report provides a summary of the progress made and work completed on BECAMP milestones for fiscal year (FY) 1988. See abstract #512. (CAW) *Keywords:* radionuclide inventory*, vegetation*, vertebrate*, radiation*, ecology/ecosystem*

514 PATTON, S.E., and L.R. ANSPAUGH. 1990. Basic Environmental Compliance and Monitoring Program (BECAMP) FY 1989 Year-End Summary Report. UCAR-10244-89, Lawrence Livermore National Laboratory, Livermore, CA, 25 pp.

The Basic Environmental Compliance and Monitoring Program (BECAMP) FY 1989 Year-End Summary Report provides a summary of the progress made and work completed on BECAMP milestones for fiscal year (FY) 1989. See abstract #512. (CAW) *Keywords:* radionuclide inventory*, vegetation*, vertebrate*, radiation*, ecology/ecosystem*

515 PATTON, S.E., and L.R. ANSPAUGH. 1991. Basic Environmental Compliance and Monitoring Program (BECAMP) FY 1990 Year-End Summary Report. UCAR-10244-90, Lawrence Livermore National Laboratory, Livermore, CA, 27 pp.

The Basic Environmental Compliance and Monitoring Program (BECAMP) FY 1991 Year-End Summary Report provides a summary of the progress made and work completed on BECAMP milestones for fiscal year (FY) 1991. See abstract #512. (CAW) *Keywords:* radionuclide inventory*, vegetation*, vertebrate*, radiation*, ecology/ecosystem*

516 PATTON, S.E., and L.R. ANSPAUGH. 1992. Basic Environmental Compliance and Monitoring Program (BECAMP) Year-End Summary Report - FY 1991. UCAR-10244-91, Lawrence Livermore National Laboratory, Livermore, CA, 30 pp.

The Basic Environmental Compliance and Monitoring Program (BECAMP) FY 1991 Year-End Summary Report provides a summary of the progress made and work completed on BECAMP milestones for fiscal year (FY) 1991. See abstract #512. (CAW) *Keywords:* radionuclide inventory*, vegetation*, vertebrate*, radiation*, ecology/ecosystem*

517 PEARSON, A.K., P. LICHT, K.A. NAGY, and P.A. MEDICA. 1978. Endocrine function and reproductive impairment in an irradiated population of the lizard *Uta stansburiana*. Radiation Research 76:610-23.

This study describes gonadal changes in lizards (*Uta stansburiana*) exposed to chronic low levels of γ radiation (1.5-10 R/day; under field conditions and attempts to evaluate endocrine involvement in these changes. Reproductive impairment in irradiated males is demonstrated during the breeding season by reduced testes weights and by seminiferous tubules devoid of germ cells. Ultrastructural morphology of Leydig cells, plasma testosterone levels, and developed accessory set structures indicate normal steroidogenesis in such males; cytology of the pituitary gonadotropes and pituitary gonadotropin content indicate normal gonadotropin levels. These findings suggest that low levels of radiation affect the spermatogenic process directly, rather than through damage to the pituitary. Comparable irradiation causes complete resorption of ovarian tissue in some female *Uta*. The oviducts are atrophic and the pituitary gonadotropes hyperactive. Resemblance of gonadotropes to those of castrated animals and reduced pituitary hormone content suggest elevated levels of gonadotropin production, probably due to the absence of ovarian steroid feedback in affected animals. The continued mitotic activity of oogonia in adult reptiles and their limited number contribute to the vulnerability of germinal tissue in irradiated female lizards. Destruction of the germ cells is accompanied by resorption of all ovarian tissue including steroidogenic elements. Thus, in females as in males, radiation appears to damage gametogenesis rather than pituitary function. (Authors) *Keywords:* reptile*, physiology*, radiation*

518 PENDLETON, R.C., and R.D. LLOYD. 1970. Environmental levels of radioactivity in Utah following Operation Pinstripe.

Radiol. Health Data Report 11:65-67.

Samples of green vegetation, tansy mustard (*Sophia pinnata*) and Kentucky bluegrass (*Poa pratensis*), collected in Utah along the fallout trajectory on the fourth day following the venting of an underground nuclear detonation at the Nevada Test Site on April 25, 1966, were analyzed for γ-emitting radionuclides at periods of three days, two months, and six months following collection. The radionuclides found included Cs-137, I-131, Mn-54, Ru-103, Ru-106, and Zr-95. These represented the spectrum of fresh fission products. Levels of radionuclides found in samples of desert shrubs collected just prior to the detonation represented the spectrum of characteristic of old fallout. The width of the fallout track was surveyed using a scintillation detector and a β-γ survey meter. Dairy cattle in the selected sampling area were not grazing during this period of time and no increase in Cs-137, I131, or Sr-90 in milk was noted. (CH) *Keywords:* vegetation*, mammal*, radiation*

519 **PENDLETON, R.C., J.J. KORANDA, W. WAGNER, P. PHELPS, R.D. LLOYD, L. ANSPAUGH, and W. CHAPMAN. 1973. Radioecological studies in Utah subsequent to the Baneberry event. In: (Nelson, D.J., Ed.) *Radionuclides in Ecosystems*, Proceedings of the Third National Symposium on Radioecology (CONE-710501), pp. 150-169.**

The Baneberry event was an underground weapons test conducted at the Nevada Test Site on the morning of December 8, 1970. Accidental venting occurred, producing a cloud of radioactivity which moved over central and northern Nevada into Utah. At the time of the Baneberry venting, the University of Utah's Department of Radiological Health and the Biomedical Division of the Lawrence Radiation Laboratory were conducting cooperative radioecological studies throughout the state of Utah. These studies were designed to document the distribution and movement of radionuclides in agricultural and natural environments in the state of Utah. As part of a program of environmental sampling, an air sampling network had been activated on 30 October 1970, and filter samples were obtained through 11 December 1970. These samples, when compared with those obtained during passage of the Baneberry cloud, enable a precise description of the radioactivity present in the state of Utah. Radioanalyses were made on air filters, water, vegetation, and animal organs obtained subsequent to the passage of the Baneberry cloud. Analyses were made by conventional NaI scintillation crystal and Ge (Li) solid-state gamma spectroscopy. Pre- and post-Baneberry air radioactivity levels will be compared. Radioisotope data for nine radionuclides will be given for air filters exposed during passage of the Baneberry cloud, which contained a highly fractionated nuclear debris. The concentration of I-131 in thyroid glands of deer, sheep, and rabbits was also measured subsequent to the Baneberry event. The buildup and decay of I-131 in various environments in Utah will be described. A large sample of sheep thyroid glands obtained near Garrison, Utah, in mid-January 1971 was found to contain low but quantitatable levels of I-131. An analysis of the human hazard as the result of the Baneberry venting based on actual measurements and conditions during cloud passage, and on predictive models, will be made. Dose calculations for various radioisotopes have been made for a child living in northern Utah. (Authors) *Keywords:* radionuclide inventory*, vegetation*, mammal*, radiation*

520 **PETERSEN, S.L., J.L. BOONE, W.M. FARISS, and V.K. WINKEL. 1998. Effects of Soil Type, Soil Depth, and Soil Amendments on Plant Establishment at Yucca Mountain, Nevada. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00097 Rev 00. Las Vegas, NV, 48 pp.**

The U.S. Department of Energy has implemented a program to investigate the feasibility of various techniques for reclaiming lands disturbed during site characterization at Yucca Mountain. As part of this program, two studies were conducted during 1993-1997 to determine whether soil treatments could be used to enhance seedling establishment and plant survival on disturbed sites. These studies compared the response of plants to different soil types (imported versus native) and soil depths (5-cm versus 20-cm), and to three soil amendments (fertilizer, polyacrylamide gel, and organic matter). Native and imported soils were distributed onto study plots during fall 1993 and sown with seeds of 14 native shrub species and one native grass species. After seeding, appropriate plots were treated with organic matter and polyacrylamide gel. Fertilizer was applied to appropriate plots one year after seeding (December 1994). During September 1994, seedling density was measured to determine whether differences in soil type and soil depth affected seedling emergence. Three years later, in 1997, plant density and cover were measured to evaluate the effects of soil type, soil depth, and soil amendments on plant survival. For several of the seeded species, seedling density was greatest on imported soils during the first year following seeding (1994). In contrast, the density of unseeded annual plants was greatest on native soil. After four years (1997), percent survival (net change in plant density) of seeded species was higher on native soil than imported soil. Total plant density of seeded species, however, remained higher on imported soil than on native soil. Thus, higher survival rates on native soils did not compensate for low plant emergence. Organic matter (alfalfa hay), applied as a surface mulch, reduced or had no effect on the density and cover of all species except spiny hopsage and fourwing saltbush. Fertilizer generally reduced the density of seeded species; however, fertilizer increased the density of annual species. Polyacrylamide gel was also ineffective in improving plant density and cover of seeded species. It was concluded that soil imported from Fortymile Wash was an adequate topsoil replacement because of high plant emergence and survival observed on this soil type. Furthermore, deeper soil was preferred over shallow soil for proper root development, plant growth, and survival. For the majority of species seeded in this study, fertilizer, PAM, and organic matter were not effective in promoting plant establishment or survival. Use of these treatments should be carefully considered prior to reclamation of Yucca Mountain and similar environments. (Authors) *Keywords:* YMSCO*, soil property*, annual plants*, perennial plants*, ecology/ecosystem*, revegetation*, methods*

521 **PHILLIPS D.L., M.G. JOHNSON, D.T. TINGEY, and C. BIGGART. 1999. Fine root responses to elevated CO_2 in a Mojave Desert ecosystem. In: Symposium Abstracts, The Ecological Society of America 84th Annual Meeting, August 8-12, 1999, Spokane, WA.**

We are using minirhizotron tubes installed to a depth of 1 m to study fine-root (< 2 mm diameter) responses to elevated CO_2 (550 ppm vs. ambient) in a FACE (Free Air CO_2 Enrichment) experiment at the Nevada Test Site in the Mojave Desert. El Niño conditions produced very high rainfall during winter 1997-1998, and root occupancy increased from 10% to 60% of the frames examined between winter and early summer 1998. There were similar increases in total root length over this time. For tubes under the evergreen shrub *Larrea tridentata*, elevated CO_2 caused increases in root length and number in the upper 25 cm, but decreases in the 25-50 cm depth range. This was also true for tubes under the drought-deciduous shrub *Ambrosia dumosa*, but with a smaller increase in shallow roots and a larger decrease in 25-50 cm depth roots. For *Larrea*, total root length and number over the entire 0-1 m depth were slightly higher for elevated CO_2 and this difference remained relatively constant over time as the roots grew. In contrast, *Ambrosia* 0-1 m root length and number totals were initially similar, but increased faster over time for the ambient CO_2 treatment. Thus, elevated CO_2 stimulated shallow root growth in both species, but the drought-deciduous shrub developed more and deeper roots under ambient CO_2 conditions. (Authors) *Keywords:* FACE*, perturbations*, climate*, perennial plants*, physiology*

522 **PHILLIPS. D.L., M.G. JOHNSON, D.T. TINGEY, C. BIGGART, R.S. NOWAK, and J. NEWSOM. 2000. Minirhizotron installation in rocky, sandy soils minimizing soil disturbance. Soil Science Society of America Journal 64:761-764.**

We developed and demonstrated the utility of a technique for installing minirhizotron tubes in sandy, rocky soils where more traditional installation methods are inadequate. The method uses a pneumatic rock-drill alternately to drill and drive drill casing into the soil. Soil particles and drilling debris are removed from the casing as it is installed. The minirhizotron tube is inserted into the drill casing and the casing is withdrawn and upward movement of the rock-drill and controls the angle of installation. Working from a platform suspended from a center-pivot elevated catwalk minimized soil disturbance. Soil contact and root ingrowth around the minirhizotron tubes were very satisfactory. This method, while fairly labor intensive, allows minirhizotron studies of root dynamics in sandy, rocky soils where they would otherwise not be possible. Also, there is much less soil compaction and disturbance than traditional installation techniques entail. (Authors) *Keywords:* FACE*, soil property*, perennial plants*, physiology*, methods*

523 **PICKLES, W.L. 1995. Observation of Temporary Plant Stress Induced by the Surface Shock of a 1-kt Underground Chemical Explosion. UCRL-ID–122557, Lawrence Livermore National Laboratory, Livermore, CA.**

The Non-Proliferation Experiment (NPE) involved carefully monitoring a 1-kt chemical underground explosion using extensive seismological measurements and low-altitude overhead imagery. Lawrence Livermore National Laboratory has conducted a study to determine whether the multispectral overhead imagery acquired during the NPE can be combined with other techniques to locate the ground zero (GZ) of an underground nuclear explosion within the seismic error ellipse. This report describes the use of such overhead images to detect the changes in plant metabolisms, normally referred to as plant stress, that appear to have been induced by the surface accelerations caused by the NPE underground explosion. The metabolic condition of the plants on the surface above the explosion point was determined using a published plant stress measuring methodology to analyze the multispectral images taken from a low-flying aircraft. The surface areas that experienced accelerations greater than 0.2 g show measurable plant stress, within 56 hours of the underground explosion, in all of the plant species. The pattern of the plants' stress generally follows the pattern of the measured surface acceleration. Seven days after the explosion, the levels of apparent plant stress had relaxed to about one-third what they were 56 hours after the explosion, while the pattern of the apparent plant stress remained the same. (Authors) *Keywords:* perturbations*, perennial plants*, physiology*, methods*

524 **PITONZO, B.J., P.S. AMY, and M. RUDIN. 1999. Effect of Gamma Radiation on Native Endolithic Microorganisms from a Radioactive Waste Deposit Site. Radiation Research 152:64-70.**

A time-course experiment was conducted to evaluate the effects of gamma radiation on the indigenous microbiota present in rock obtained from Yucca Mountain, Nevada Test Site. Microcosms were constructed by placing pulverized Yucca Mountain rock in polystyrene cylinders. Continuous exposure (96 h) at a dose rate of 1.63 Gy/min was used to mimic the near-field environment surrounding waste canisters. The expected maximum surface dose rate from one unbreached canister designed to contain spent nuclear fuels is 0.06 Gy/min. Considering the current repository packing design, multiple canisters within one vault, the cumulative dose rate may well approach that used in this experiment. The microbial communities were characterized after receiving cumulative doses of 0, 0.098, 0. 58, 2.33, 4.67, 7.01 and 9.34 kGy. Radiation-resistant microorganisms in the pulverized rock became viable but nonculturable (VBNC) after a cumulative dose of 2.33 kGy. VBNC microorganisms lose the ability to grow on media on which they have routinely been cultured in response to the environmental stress imposed (i.e. radiation) but can be detected throughout the time course using direct fluorescence microscopy techniques. Two representative exopolysaccharide-producing isolates from Yucca Mountain were exposed to the same radiation regimen in sand microcosms. One isolate was much more radiation-resistant than the other, but both had greater resistance than the general microbial community based on culturable counts. However, when respiring cell counts (VBNC) were compared after irradiation, the results would indicate much more radiation resistance of the individual isolates and the microbial community in general. These results have significant implications for underground storage of nuclear waste as they indicate that indigenous microorganisms are capable of surviving gamma irradiation in a VBNC state. (Authors) *Keywords:* YMSCO*, geology*, microbiota*, radiation*

525 **PITONZO, B.J., P.S. AMY, and M. RUDIN. 1999. Resuscitation of microorganisms after gamma irradiation. Radiation Research 152:71-75.**

Microbiological analysis of rock exposed to γ-radiation doses between 0 and 9.34 kGy indicated that some microorganisms became viable but nonculturable (VBNC) and lost metabolic capacity as measured by BIOLOG microtiter plates. To investigate this phenomenon, portions of irradiated rock were placed at 4°C for 2 months in an attempt to resuscitate the microbes to a culturable state. Culturable heterotrophs were enumerated and BIOLOG plates were used to determine the metabolic capability of the microbial community. Culturable bacteria that had previously been nonculturable were found at all doses. The number of colony types decreased from 26 in the nonirradiated control rock to between 9 and 10 in rock irradiated at doses ranging from 2.34 to 9.34 kGy. BIOLOG plates indicated partial recovery of metabolic capacity in all the samples tested. Fatty acid methyl ester analysis of the recovered isolates using the MIDI system (Microbial ID, Inc.) yielded three distinct groups of related bacteria. All resuscitated isolates clustered with the original nonirradiated isolates at the genus level, and 92% of them clustered at the species level. These results indicate that microbes were likely resuscitated from a VBNC state. (Authors) *Keywords:* geology*, microbiota*, physiology*, radiation*

526 **POTTER, G.D. 1977. Transuranic Elements in Terrestrial Animals and the Environment: An Introduction. In: *Transuranics in Natural Environments*. White, M.G., and P.B. Dunaway (Eds.). NVO-178, Nevada Applied Ecology Group, U.S. Energy Research & Development Administration, Las Vegas, NV, pp. 379-383.**

This discussion provides background information to the session on the "Transuranic Elements in Terrestrial Animals." Briefly outlined are some of the historical events leading to the introduction and dispersion of the transuranic elements into the biosphere, to the establishment of the Nevada Applied Ecology Group (NAEG), and to the studies conducted by the Environmental Monitoring and Support Laboratory (EMSL-LV) and the University of Nevada-Las Vegas involving the transuranics distributed by the "safety shots" and the nuclear weapons testing program at the Nevada Test Site and the

Tonopah Test Range. These studies are described in relation to the overall objectives of the NAEG program. Other potential sources of the transuranic radionuclides are also discussed. (Author) *Keywords:* NAEG*, radionuclide inventory*, vertebrates*, radiation*

527 **QUIRING, R.F. 1968. Climatological data Nevada Test Site and Nuclear Rocket Development Station. U.S. Dept. of Commerce Environmental Science Services Administration Report ERLTM-ARL 7, 177 pp.**

Climatological data for the Nevada Test Site and Nuclear Rocket Development Station were compiled. The data and analyses are presented as samples from substantially different topographic environments to show the salient features of the seasonal and diurnal variations of wind and temperature near ground level and aloft. An evaluation of precipitation data for a 20 station network on the test site and a 5-yr climatological summary for the continuously manned Yucca weather station are included. (Author) *Keywords:* climate*

528 **RAGSDALE, H.L., and W.A. RHOADS. 1974. Four-year post-exposure assay of vegetation surrounding Project Pinstripe: demonstration of the utility of delayed damage appraisals. Radiation Botany 14: 229-236.**

This report illustrates the feasibility of using temporally-delayed vegetation assays to determine radiation damage, by documenting the radiation damage resulting from the accidental venting of radioactive materials during Project Pinstripe, Frenchman's Flat, Nevada Test Site, in April, 1966. Evidence of desert shrub radiation damage was first observed and photographed in April, 1968. Systematic study of the vegetation was initiated in October, 1970, and evidence of radiation damage documented over 72.9 hectares adjacent to the vent. Beta doses were estimated at 15-21 krads based on gamma exposure dose measurements. The minimum beta dose estimate was substantially greater than the theoretical lethal dose for the shrub, *Larrea divaricata*. Radiation damage to the shrubs, *Larrea divaricata*, *Ephedra funerea*, and *Atriplex confertifotia* was expressed as differential bud mortality, partial death of shrub crowns with and without crown regrowth, and total shrub crown death without crown regrowth. Each of the shrub populations was statistically different from its control population with respect to the distribution of individuals among damage classes. Generally, damage patterns were similar to those observed at two previously-studied Plowshare events. (Authors) *Keywords:* perennial plants*, radiation*

529 **RAKESTRAW, D.L., E.A. HOLT, and K.R. RAUTENSTRAUCH. 1995. Diet of Desert Tortoises at Yucca Mountain, Nevada, and Implications for Habitat Reclamation. U.S. Department of Energy, Civilian Radioactive Waste Management System Management snd Operating Contractor Report B00000000-01717-5705-00028. Las Vegas, NV, 18 pp.**

The diet of desert tortoises at Yucca Mountain was assessed during 1992 to 1995 using a combination of feeding observations and scat analysis. Feeding observation data (1993 through 1995) showed that tortoises fed on a wide variety of items. The most frequently eaten items were forbs and annual grasses. These two forage groups comprised more than 90% of all bites taken. Analysis of scat (1992 and 1993) also showed that grasses and forbs were the most common groups, making up more than 80% of the composition of scat. Yearly differences between proportions of species in the diet were observed and were most likely attributable to differences in plant productivity, which is linked to rainfall patterns. Nonnative species were an important component of the diet in all years, accounting for 13 to 50% of all bites observed and 6 to 24% of scat contents. A list of all items encountered in the diet is provided. To facilitate reclamation of desert tortoise habitat disturbed by the Yucca Mountain Site Characterization Project, native forage species that should be included in reclamation seed mixes, when feasible, were identified. Although shrubs make up only a small proportion of the diet, they should also be included in reclamation efforts because they provide habitat structure, tortoise cover sites, and microhabitats amenable to seed germination and seedling establishment. In addition, non-native species should not be planted on reclaimed sites and, if necessary, sites should be recontoured and soil compaction reduced prior to planting. (Authors) *Keywords:* YMSCO*, desert tortoise*, invasive species*, perennial plants*, annual plants*, nutrition/diet*

530 **RAKESTRAW, D.L., P.E. LEDERLE, and K.R. RAUTENSTRAUCH. 1998. Efficacy of Relocating Desert Tortoises for the Yucca Mountain Site Characterization Project. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00032 Rev 00. Las Vegas, NV, 21 pp.**

The U.S. Fish and Wildlife Service (FWS) authorized the incidental take of tortoises by the U.S. Department of Energy (DOE) during site characterization at Yucca Mountain and required DOE to relocate tortoises out of harm's way if site characterization activities could not be modified or moved to areas not containing tortoises or tortoise burrows. This report summarizes the results of the relocation efforts, evaluates the effectiveness of the relocations, and provides guidelines for distances to relocate tortoises. A total of 23 of 28 relocations were associated with 4 large operations: the Exploratory Studies Facility, the Fran Ridge borrow pit, the muck storage area, and the topsoil storage area. After being fitted with radio transmitters, relocated tortoises were intensively monitored using radio telemetry. Success of relocations was assessed by determining the survival rates of relocated tortoises, the number of times tortoises returned to the construction areas they were removed from, whether an increase in the incidence of upper respiratory tract disease was observed in relocated tortoises, and whether post-relocation home range sizes differed from those of nonrelocated tortoises. Of the 28 tortoise relocations during 1991-1995, only one death occurred as a result of human activities. One tortoise was killed on an access road after it returned to the area from which it was moved. Two other relocated tortoises are known to have died: one, 8 months after being relocated; and the other, after being lost for 12 months, was found dead 20 months later. The causes of these two deaths were not attributable to construction activities or to the relocations. Both were young tortoises, an age group that has naturally high mortality rates. Of the 28 relocated tortoises, only three returned to construction sites and had to be relocated again. Of these three tortoises, one had to be moved one additional time, another had to be moved two additional times, and the third tortoise had to be moved seven additional times. No increase in the incidence of clinical signs or antibody levels associated with upper respiratory tract disease was observed in relocated tortoises. Positive tests for antibodies of the mycoplasma that causes the disease were less frequent in the relocated tortoises than in the rest of the Yucca Mountain population. All relocations involved moving the tortoise as short a distance as possible, and many were released within or near their established home range. Less than half of the relocated tortoises showed movement patterns, as indexed by home range size, that were different from the rest of the Yucca Mountain population. Six individuals used larger home ranges and four used smaller home ranges than other tortoises. Only one animal made long-distance movements following relocation; this animal was relocated approximately 5 km. Based on the results of these relocations, adult tortoises should be relocated 200 to 1,000 m away from construction activities, immature tortoises should be relocated 100 to 400 m away, and juveniles should be relocated 100 - 200 m from construction activities. (Authors) *Keywords:* YMSCO*, perturbations*, desert tortoise*, ecology/ecosystem*, life history*, methods*

531 **RAKESTRAW, D.L., K.R. RAUTENSTRAUCH, and J.M. MUELLER. 1994. The Desert Tortoise Program for the Yucca Mountain Site Characterization Project. In: The Desert Tortoise Council Proceedings of 1994 Symposium, pp. 186-187. Desert Tortoise Council, Inc., San Bernadino, CA.**

This abstract presents the objectives of the Desert Tortoise Program: to evaluate and mitigate impacts of YMP activities on desert tortoises, develop and test the efficacy of mitigation techniques, and obtain site-specific information on desert tortoise biology needed to achieve these other objectives. Most site characterization activities will be similar to mining activities and will result in two distinctly different types of disturbances. First, there will be many small (< 2 ha each) disturbances such as drill pads, study pits, access roads, and powerlines. Second, there will be a small number (3- 5) of large (> 2 ha) disturbances. After reviewing project plans and descriptions of the types of disturbances anticipated, we separated potential impacts of these disturbances into two categories: direct or immediate impacts (e.g., habitat loss or death due to burial or crushing) and indirect or cumulative impacts (e.g., habitat fragmentation, altered forage availability). The Desert Tortoise Program is divided into two suites of interrelated procedures and studies, one of which addresses immediate, direct impacts, and the other cumulative, indirect impacts anticipated. (Authors) *Keywords:* YMSCO*, perturbations*, desert tortoise*, ecology/ecosystem*, life history*, management*

532 **RAKESTRAW, D.L., D.L. ALLEN, J.L. BOONE, and M.K. COX. 1998. Bats of Yucca Mountain, Nevada. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00050 Rev 00 Draft. Las Vegas, NV, 17 pp.**

An understanding of the animal community found at Yucca Mountain was needed to conduct site characterization activities in a manner that minimized significant adverse environmental impacts and to evaluate potential impacts of future project activities. Although information had been reported on some types of animals in the area, relatively little information was available on the bat community at Yucca Mountain. Information on the bat community became more important in 1989 when the spotted bat was identified as a candidate for listing as threatened or endangered. In 1994, eight additional bat species that may occur at Yucca Mountain were added to the list of candidates. During 1991-1993, surveys were conducted at Yucca Mountain and at sites on or near Pahute Mesa in the northern portion of the U.S. Department of Energy's Nevada Test Site to describe the bat community in the Yucca Mountain area and to determine the possibility that spotted bats and other protected species occurred at Yucca Mountain. Seven (possibly eight) species of bats were captured near Yucca Mountain. Based on a literature review, nine other bat species also may occur in the area. Two of the species captured at Yucca Mountain (long-legged myotis and fringed myotis), and a third possibly captured there (western small-footed myotis) were among the species added to the list of candidates in 1994. Despite survey efforts in the area, the spotted bat was not captured or heard at Yucca Mountain. However, vocalizations of this species were heard and recorded 50 km north of Yucca Mountain near Pahute Mesa, and specimens were captured at Pahute Mesa in 1996 by other Department of Energy contractors. Seven other bat species were captured near Pahute and Rainier mesas. In all, six of the species captured at Yucca Mountain or near the mesas had not been captured or recorded on the Nevada Test Site. In 1996, all bats possibly occurring at Yucca Mountain were removed from the list of candidate species due to a lack of information on population abundance and trends of the species. However, these species are still considered either sensitive by the U.S. Bureau of Land Management or protected by the State of Nevada. As additional biological information is obtained, the species may again become candidates for listing, therefore the Department of Energy should monitor the legal status of these species. (Authors) *Keywords:* YMSCO*, mammal*, sensitive animals*, ecology/ecosystem*

533 **RAKESTRAW, D.L., P.E. LEDERLE, K.R. RAUTENSTRAUCH, and R.G. GOODWIN. 1999. Cover Use and Movement**

Patterns of Hatchling Desert Tortoises at Yucca Mountain, Nevada. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00073 Rev 00. Las Vegas, NV, 11 pp.

This report summarizes data collected at Yucca Mountain during 1993-1994 on the movement patterns and use of cover by desert tortoises from the time they emerged from their nests in August-October, until they enter their hibernacula in November- December. Forty-eight hatchling desert tortoises were captured as they emerged from 28 nests, and were fitted with radio transmitters. Using radiotelemetry equipment, these tortoises were located 904 times and information on location, cover-type, and microhabitat were recorded. Using location information, distance moved per day and distance from the tortoise's nest to its hibernaculum were calculated. Hatchling desert tortoises used burrows more often (62% of observations) than other types of cover during the first few months of their lives. Hatchlings also used pallets (partially excavated areas or aboveground cover) under shrubs and rocks, and were seen in the open away from cover. When they were using burrows, they most often used burrows under shrubs (52% of all observations in burrows). The burrows used by hatchlings were most often constructed by rodents (48% of observations in burrows in 1993 and 71% in 1994). Hatchling tortoises monitored until entering a hibernaculum used an average of 6.5 burrows. Because desert tortoise hatchlings are small, cryptically colored, and use burrows that are very common in the area, they are very difficult to find. Even when using radiotelemetry, biologists were able to see the tortoises only 58% of the times they were located. Hatchlings moved from their previous location during 67% of the observations in 1993 and 55% in 1994. However, when tortoises moved, they most often moved less than 20 m. Hatchlings moved more than 50 m per day 28 times, but moved more than 100 m per day only three times. The average distance between nests and hibernacula was 92 m in 1993 and 106 m in 1994. Based on this information, relocating hatchling tortoises 100 to 200 m from construction sites should be sufficient to minimize the chance of them returning to the site. (Authors) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*

534 RAKESTRAW, D.L., J.M. MUELLER, K.R. SHARP, K.K. ZANDER, K.R. RAUTENSTRAUCH, and P.E. LEDERLE. 1999. Egg Production by Desert Tortoises at Yucca Mountain, Nevada. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00087 Rev 00. Las Vegas, NV, 12 pp.

To assess and monitor the potential impacts of the Yucca Mountain Site Characterization Project, reproductive rates (annual fecundity) of desert tortoises were determined using x-rays during 1993-1995 at Yucca Mountain, Nevada. Results of the analyses of impacts on annual fecundity were included in a separate report that summarized impacts on numerous aspects of tortoise life history (CRAMS M&O 1999). This report further summarizes the data collected during these efforts by describing annual egg production (referred to in this report as annual fecundity) of desert tortoises and evaluating the relationships among female size, the number of eggs per clutch, the number of clutches per year, and annual fecundity. The smallest tortoise to lay eggs was 209 mm carapace length (CL) and about 19-20 years old. This is larger and older than desert tortoises in other areas. When tortoises laid eggs, the number of eggs per clutch (clutch size) ranged from one to ten. For all tortoises monitored, the number of clutches per year (clutch frequency) ranged from zero to two, and the total number of eggs laid per year (annual fecundity) ranged from zero to sixteen. Clutch size and annual fecundity were related to female size (i.e., larger females produced more eggs), but clutch frequency was not. Mean CL of desert tortoises that produced eggs was 247.4 mm (SE = 2.5), and mean annual fecundity was 8.2 eggs (SE = 0.5). Based on linear regression, the predicted annual fecundity for a tortoise at the beginning of its reproductive life (CL = 209) was 3 eggs. As they grow, the regression equation predicted an increase of one egg per 7-mm increase in size. Thus, while a 209-mm tortoise lays about 3 eggs per year, a 280-mm tortoise lays about 12 eggs per year. Tortoises produced an average of 1.5 clutches per year. Tortoises that had two clutches in a year produced a similar number of eggs in the first (x = 5.1 eggs) and second (x = 4.8 eggs) clutches. Tortoises that laid a single clutch produced, on average, 0.9 more eggs per clutch than tortoises that produced two clutches, but the total number of eggs produced in two clutches was greater. (Authors) *Keywords:* YMSCO*, desert tortoise*, life history*

535 RAMSPOTT, L.D., R.L. BRAUN, and W.F. WADLEIGH. 1970. Mineral composition, $C0_2$ content, and grain density of drill hole samples from Yucca Flat, Nevada Test Site. USAEC Report UCRL-50915, 15 pp.

Mineral composition, $C0_2$ content, and grain density have been determined for 148 samples from 108 drill holes in Yucca Flat, Nevada Test Site. The amounts of calcite, dolomite, and quartz were quantitatively determined by x-ray diffractometry using an internal standard. All other minerals were identified, and qualitative estimates of the x-ray intensities of zeolite, feldspar, and illite are given. The mean weight-percent values for 119 alluvium samples are: calcite 5.9, dolomite 4.5, and $C0_2$ 4.77. The median values for the same samples are: calcite 2.5, dolomite 1.5, and $C0_2$ 3.60. The modal classes are: calcite 1-2

(wt%), dolomite 0-1, and $C0_2$ 0-1. Although two-thirds of the holes had only cuttings samples for the alluvium interval, analysis of size fractions of suitable samples indicates that cuttings samples provide a usable indicator of the carbonate content of the original rock. In general, grain density does not correlate quantitatively with any one mineral, but in a suite of samples from one drill hole the correlation coefficient between dolomite and grain density was 0.933. (Authors)
Keywords: geology*, soil property*

536 RASMUSON, K.E. 1998. Interim Report: Plant and Soil Related Processes Along a Natural Thermal Gradient at Yucca Mountain, Nevada., U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00098 Rev 00. Las Vegas, NV, 57 pp.

Yucca Mountain currently is being studied by the Department of Energy (DOE) as a potential site for a monitored geologic repository for spent nuclear fuel and high level radioactive waste. Heat generated from interred waste is expected to warm the surrounding rock and eventually warm the soil above the repository, a process termed thermal loading. Impacts of increased soil temperatures on the ecosystem above the repository will be evaluated in the Environmental Impact Statement (EIS) for Yucca Mountain. However, because little information exists describing the current variability in soil temperatures and plant communities across natural soil temperature gradients at Yucca Mountain, the possible effects of thermal loading on the ecosystem are difficult to predict. Thus, a field study was initiated at Yucca Mountain to characterize the environment with respect to existing soil temperature regimes. This report summarizes preliminary results of the field study. The results were evaluated in relation to increases in soil temperatures predicted by two thermal loading models developed by scientists at the Los Alamos National Laboratory (LANL; Robinson et al. 1998) and by scientists at the Lawrence Berkeley National Laboratory (Bodvarsson and Bandurraga 1996). Increases in soil temperature were predicted by Robinson et al. (1998) to vary with soil moisture and depth. Increases in soil temperature were expected to begin about 200 years after waste emplacement in the repository, and to reach maximum levels in about 700 years. The model predicted that heat would dissipate towards the surface, and at a depth of 2 m the temperature would increase about 0.8 and 6 °C for wet and dry soils, respectively. At a depth of 1 m, the predicted soil temperature increase was about 0.4-3.0 °C, and nearer the surface, at 50- and 15 cm, the predicted increases were about 0.2-1.5 °C and 0.06-0.45 °C, respectively. Bodvarsson and Bandurraga (1996) predicted that temperature increases would be around 10 °C at the bedrock surface. The field study was conducted on eight sites at Yucca Mountain which differed in natural thermal load due to aspect and elevation. At each site, soil temperature and moisture were monitored at 15 and 45 cm (45 cm was generally the maximum depth that soil cells could be placed at the study sites), and differences in plant community and ecosystem processes were evaluated. Study results indicate that, while changes in soil temperatures due to thermal loading at Yucca Mountain could result in changes in plant community composition, it is unlikely that temperature changes of the magnitude predicted by the LANL model would result in the demise of all plant species. Under the influence of thermal loading, higher elevation north-facing slopes (cooler sites) could experience temperatures similar to those measured at lower elevation south-facing slopes (warmer sites). Therefore, it is possible that plant community composition within the repository footprint could change towards a community similar to those presently supported on warmer sites. However, during prolonged droughts, temperature increases of 10 °C predicted by Bodvarsson and Bandurraga (1996) may cause more drastic changes in community composition and could result in annual-dominated communities within the affected area. Such a change could affect rates of water infiltration, soil temperatures, nutrient

cycling, fire cycles and potential erosion rates. (Authors) *Keywords:* YMSCO*, hydrology*, soil property*, perturbations*, microbiota*, perennial plants*, ecology/ecosystem*, physiology*

537 RAUTENSTRAUCH, K.R. 1997. Differences in Burrow Use by Adult Male and Female Desert Tortoises. In: The Desert Tortoise Council Proceedings of 1997-1998 Symposia, p. 93. Desert Tortoise Council, Inc., San Bernadino, CA.

We monitored seasonal use of cover by radio marked adult desert tortoises *(Gopherus agassizii)* at Yucca Mountain, Nevada, to describe the number and types of burrows used and to evaluate differences in cover use between sexes. In general, we found tortoises in burrows most often during the hottest and coldest months and in pallets and away from cover most often during months with moderate temperatures. In addition, we detected differences between males and females in the depth of burrows used and in the types of cover used seasonally. We found males deeper in burrows and in deep burrows (i.e., burrows > 1 m deep) more often than females during all seasons. In addition, males used more deep burrows per year (x = 4.9, SD = 0.32) than females (x = 3.0, SD = 0.21). Thirty-nine and 27% of the burrows used per year by males and females, respectively, were deep. Males and females used a different number of burrows and different types of cover seasonally. During spring, females used more burrows (x = 4.3 vs. 3.4), were found away from cover more often (25 vs. 21 %), and were found in deep burrows about half as often (17 vs. 33%) as males. This pattern was reversed during fall

(September-October), which is when most courtship activity was observed at Yucca Mountain. Females used fewer burrows (x = 4.0 vs. 5.3), were away from cover less often (7 vs. 16%), and were found in deep burrows only slightly less often (37 vs. 40%) than males during fall. Many of these seasonal differences probably were related to the annual reproductive cycle and to differences in the timing of hibernation between males and females. (Author) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*

538 **RAUTENSTRAUCH, K.R., and E.A. HOLT. 1994. Selecting an Appropriate Method for Estimating Desert Tortoise Home Range Size and Location. In: The Desert Tortoise Council Proceedings of 1994 Symposium, pp. 172-173. Desert Tortoise Council, Inc., San Bernadino, CA.**

We are comparing the movements of potentially affected and unaffected (control) desert tortoises (*Gopherus agassizb*) to evaluate the effects of the U.S. Department of Energy, Yucca Mountain Site Characterization Project, on this species. The methods we choose to summarize and quantify movements must provide meaningful estimates of the locations of home ranges and unbiased indices of their sizes. In addition, the methods must provide these estimates using a reasonable number of locations and must have assumptions that are not violated by the movement patterns of desert tortoises. To select an appropriate method for quantifying movements, we compared the sample size requirements, assumptions, and results of six methods using 64 sets of locations. Each of these data sets contained > 60 locations of one tortoise during one activity season (i.e., the period starting when a tortoise exited its hibernaculum in the spring and ending when it entered its hibernaculum in the fall). Dates of locations were distributed evenly throughout the activity season. We concluded that the 100% minimum convex polygon is a valid method for identifying the maximum area used by tortoises at Yucca Mountain during one.year if those tortoises were located >_ 60 times during an activity season. Only 25% of the 64 data sets met the assumption of this technique that locations are distributed uniformly throughout the home range. Therefore, the minimum convex polygon method should not be used to identify core areas or answer other questions that require removing outer proportions of the locations. The sample size correction factor presented by Jennrich and Turner (1969) overestimated home range size by as much as 200% and should not be used for desert tortoise data. The bivariate normal ellipse (Jennrich and Turner 1969) and weighted bivariate normal ellipse (Samuel and Garton 1985) calculations should not be used to calculate home range size of desert tortoises because they are based on an assumption that is not met by the movement patterns of desert tortoises we studied. These techniques assume that an animal uses the arithmetic-mean center of its home range the most and the probability of it being found at distances from that center is based on a bivariate normal function. Only 5% of 64 data sets met that assumption. In addition, > 80 locations were required to obtain precise estimates of home range size for all of the data sets. The general pattern of movement of desert tortoises at Yucca Mountain is to use an area centered around a burrow or group of burrows for a time and then move to other, sometimes distant groups of burrows throughout the activity season. It is therefore important to obtain locations throughout the season. Home range calculations that allow multiple centers of activity fit this pattern of movement better than those which calculate only one activity center, such as the minimum convex polygon and bivariate normal ellipse. Three techniques to consider are the cluster method (Kenward 1987), harmonic mean analysis (Dixon and Chapman 1980), and kernel analysis (Worton 1989). The techniques all require a relatively large (> 60) number of locations for desert tortoises at Yucca Mountain. (Authors) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*, methods*

539 **RAUTENSTRAUCH, K.R., and E.A. HOLT. 1999. Movement Patterns of Desert Tortoises at Yucca Mountain. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00049 Rev 00. Las Vegas, NV, 19 pp.**

In response to the Nuclear Waste Policy Act of 1982 and the Nuclear Waste Policy Amendments Act of 1987, the U.S. Department of Energy developed and is implementing the Yucca Mountain Site Characterization Project. As part of a program conducted to monitor and mitigate the impacts of that project on desert tortoises, the movements of radiomarked tortoises were monitored at Yucca Mountain during 1989-1995. This report describes the results of that monitoring and summarizes information on the home range size, annual movement patterns, and long-distance movements of desert tortoises at Yucca Mountain. This study fulfills the requirement that DOE study the movements of desert tortoises, which was set forth in the incidental take provisions of the Biological Opinion for site characterization activities. Adult (i.e., greater than 180 mm carapace length) male tortoises had relatively large home ranges, varying in size from 4 to 197 ha (10-4.92 acres). Adult females had home ranges of 2 to 58 ha (5-145 acres). Immature tortoises (100-180 mm long) used smaller areas of 1 to 16 ha (3-40 acres), and juveniles (less than 100 mm long) used very small areas of 0.1 to 7 ha (0.3-18 acres). Home ranges of adult desert tortoises at Yucca Mountain were about twice as large as those reported for desert tortoises at three other sites. All sex/size classes of tortoises moved infrequently from November through February, the period when most tortoises were hibernating. After emerging from hibernation in March-April until it became very hot and forage dried up in mid-June, tortoises moved long distances relative to the rest of the year. Distance moved and frequency of movements by females, immatures, and juveniles decreased beginning in June and remained low through August. Distance moved and frequency of movements by males also decreased in June, but unlike other classes, males began moving long distances and more often again by mid-July. During August and September, distance moved and frequency of movements of all classes increased, but those of males were substantially larger than other classes, possibly because males were searching for females with which to mate. Ten of 210 radiomarked tortoises at Yucca Mountain made long-distance movements of 2 km to more than 10 km. Some of these tortoises settled into new, well defined home ranges after moving, and others continued to move during the study. Six of these 10 tortoises were relatively small adult males (180-244 mm long). Although the exact proportion of tortoises at Yucca Mountain that made long-distance movements cannot be determined, this information does indicate that a portion of the population regularly moves to new areas, possibly enhancing gene flow among populations in this region. The information in this report has been used to improve methods for protecting tortoises at Yucca Mountain from construction activities. Conclusions were made regarding the size of buffers to search around areas to be disturbed, distances to relocate tortoises from construction sites, and actions to ensure activities and facilities do not disrupt the movements of desert tortoise at Yucca Mountain. (Authors) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*

540 RAUTENSTRAUCH, K.R., and T.P. O'FARRELL. 1998. Relative Abundance of Desert Tortoises on the Nevada Test Site. Southwestern Naturalist (43):407-411.

To better understand the distribution and relative abundance of desert tortoises in the northern part of their range in the Mojave Desert, we conducted surveys on the Nevada Test Site (NTS) at elevations of 860 to 1,615 m during 1981 to 1986. We present results of those surveys and describe abundance of desert tortoises there relative to vegetation associations, elevation, and geologic origin of surrounding mountains. (Authors) *Keywords:* YMSCO*, desert tortoise*, vegetation*, ecology/ecosystem*

541 RAUTENSTRAUCH, K.R., G.A. BROWN, and R.G. GOODWIN. 1994. The Northern Boundary of the Desert Tortoise Range on the Nevada Test Site, EGG 11265-1103, EG&G Energy Measurements, Las Vegas, NV, 20 pp.

A study was conducted in 1993 to more accurately define the northern boundary or the range of desert tortoises (*Gopherus agassizii*) on the Nevada Test Site. Eighty-six transects totaling 338.2 km were walked along this boundary and 53 tortoise sign were recorded. Tortoise sign was found all along the northern edge of Jackass and Frenchman flats. Sign was found north of those valleys only in the Calico Hills at the south end of Topopah Valley and the CP Hills at the extreme southern end of Yucca Flat. A revised map of the range of desert tortoises on NTS is presented. This information can by used by the U.S. Department of Energy to determine whether activities conducted along or near this boundary will affect desert tortoises. (Authors) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*

542 RAUTENSTRAUCH, K.R., A.L. HUGHES, and D.L. RAKESTRAW. 1997. Hibernation Behavior of Desert Tortoises at Yucca Mountain, Nevada. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00031 Rev 00. Las Vegas, NV, 13 pp.

The U.S. Department of Energy conducts preactivity surveys as part of its program to protect the threatened desert tortoise (*Gopherus agassizii*) from impacts of the Yucca Mountain Site Characterization Project. The information obtained from these surveys is used to develop plans to protect tortoises that may be harmed during construction. If tortoises or evidence of tortoises are found during a preactivity survey, a resurvey usually is conducted no more than five days prior to initiation of ground clearing to find and remove tortoises from the site. If tortoises are near the site but not in immediate danger, a biologist may monitor those animals during ground clearing or other potentially harmful activities. Tortoises are known to hibernate during the winter, but may become active on warm or rainy days. If tortoises at Yucca Mountain, which is along the northern edge of this species' range, remain in their hibernacula during the winter, there would be no need to resurvey sites or monitor tortoises during construction during the hibernation period. Because little was known about hibernation chronology at Yucca Mountain, the dates that radiomarked tortoises entered and exited hibernacula during the winters of 1991-92 through 1994-95 were determined. In addition, tortoises were monitored during winter to determine whether they became active periodically. Ninety-eight percent of all tortoises entered hibernation by November 15 during this study. By February 15, 98% of all tortoises were still in their hibernacula. From November 15 through February 15, 4,093 of 4,110 observations (99.6%) were of tortoises in burrows. About half of the 11 observations of tortoises out of burrows during this period were animals that had been handled or otherwise disturbed. These data indicate that, for management purposes, the winter inactivity period of tortoises at Yucca Mountain is November 15 through February 15. Because almost all tortoises remained inactive during this winter period, a resurvey to find tortoises that may have entered a site since the preactivity survey is not necessary if that preactivity survey is conducted after November 15 and construction begins before February 15. In addition, there usually will be no need to monitor tortoises adjacent to construction activities during this winter period. Final site preparation (e.g., collapsing burrows and relocating tortoises) can be done at any time after the Yucca Mountain Site Characterization Office has determined exactly where ground clearing will occur. It is recommended that tortoises be disturbed as little as possible during winter surveys to avoid causing them to become active. If a tortoise is handled or otherwise disturbed during a winter survey, that animal should be monitored periodically, if it is close to a construction site, to ensure that the tortoise does not become active and enter the site. (Authors) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*

543 **RAUTENSTRAUCH, K.R., P.E. LEDERLE, and D.L. RAKESTRAW. 1999. Environmental Baseline File for Biological Resources. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5700-00009 Rev 00. Las Vegas, NV.**

This document describes the biological resources that may be affected by the construction, operation and monitoring, and closure of a geologic repository at Yucca Mountain, Nye County, Nevada. It is organized into six chapters. The first is an introduction. The second is a review of studies and descriptions of biological resources that could provide information for evaluating the effects of the proposed action. The third describes the biological resources in areas that may be affected by the proposed action. The fourth identifies and discusses opposing views and conflicting opinions about past and proposed methods for evaluating effects of the proposed action on biological resources. The fifth chapter identifies data not currently available that may be needed to complete the EIS. Appendix A of this document is a list of the scientific names of all plant and animal species mentioned in this document. Appendix B is a list of invertebrate taxa found at Yucca Mountain. Appendices C and D contain summaries of the land cover types along the transportation corridors and intermodal transfer stations. Appendices E through O are lists of biological resources within or near the proposed rail corridors, heavy-haul routes, and intermodal transfer stations. (CAW) *Keywords:* YMSCO*, management*, perturbations*, sensitive plants*, sensitive animals*, vegetation*, invertebrate*, vertebrate*, ecology/ecosystem*

544 **RAUTENSTRAUCH, K.R., A.L. RAGER, and D.L. RAKESTRAW. 1998. Winter Behavior of Desert Tortoises in Southcentral Nevada. Journal of Wildlife Management (62):98-104.**

We studied the activity patterns of desert tortoises (*Gopherus agassizii*) during 4 winters at Yucca Mountain, Nevada, to evaluate methods for protecting tortoises during winter construction activities. Adult males tended to enter and exit hibernacula later than adult females, and juveniles exited hibernacula earlier than other tortoises. Ninety-eight percent of all tortoises entered hibernacula by 15 November, and 98% of tortoises were still in their hibernacula on 15 February. We found tortoises in burrows during 4,102 of 4,119 observations (99.6%) from 15 November to 15 February. About half of the observations of tortoises out of burrows during that period were animals that were handled or otherwise disturbed. Because most tortoises remained inactive, we recommend that daily monitoring of construction equipment and daily searches of sites being cleared of vegetation, excavated, or similarly disturbed are unnecessary in southcentral Nevada from 15 November to 15 February, if sites are thoroughly searched for tortoises during that period, and all tortoises potentially trapped in burrows or otherwise injured are moved to safe, undisturbed areas. To avoid causing tortoises to become active, we also recommend that tortoises be disturbed as little as possible during winter surveys. (Authors) *Keywords:* YMSCO*, desert tortoise*, ecology/ecosystem*

545 **RAUTENSTRAUCH, K.R., P.E. LEDERLE, D.L. RAKESTRAW, and J.M. MUELLER. 1999. Effects of the Yucca Mountain Site Characterization Project on Desert Tortoises. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00029 Rev 00. Las Vegas, NV.**

This report summarizes the development, implementation, and results of the desert tortoise monitoring program proposed in the *Biological Assessment of the Effects of Site Characterization Activities on the Endangered Desert Tortoise* (DOE 1989). As part of the program, studies were conducted during 1992-1995 to evaluate the potential direct and indirect impacts of Yucca Mountain site characterization activities on desert tortoises.. Three types of direct impacts were monitored: deaths resulting from site characterization activities, habitat loss, and relocation of tortoises and tortoise nests from areas to be disturbed. These impacts were monitored by counting the number of tortoises killed or injured due to site characterization activities, mapping areas disturbed, and monitoring the success of relocating tortoises from areas to be disturbed by construction activities. Indirect impacts are those that may occur later in time and are the more subtle and possibly cumulative effects of exposure to chronic levels of disturbances. Indirect impacts were evaluated by measuring eight response variables from radiomarked tortoises in a high-impact treatment area (near large-scale, long-term disturbances), an area-wide treatment area (throughout the Yucca Mountain area where smaller-scale activities occurred), and a control area (where no site characterization activities occurred). Demographic variables measured included annual reproductive output, adult survival, and annual growth. Behavioral variables measured included annual home range size, shift in annual centers of activity, activity levels, and the number of burrows used annually. The presence of antibodies to the causative agent for upper respiratory tract disease was also measured. The direct impacts of site characterization activities on the tortoise population at Yucca Mountain were minimal. From July 1992 through July 1996, 110 ha of desert tortoise habitat were disturbed, and an additional 14-ha area was fenced to exclude tortoises. Four tortoises were killed as a result of site characterization activities; all were killed on roads. The relocations of 27 of 28 tortoises were considered successful; one tortoise was killed crossing a road near the construction site after being relocated. Minimal direct impacts are attributed to low tortoise abundance in the area and adherence to the mitigation measures outlined in the Biological Opinion (Letter No. 1-5-90-F-6 from R. McNatt, U.S. Fish and Wildlife Service Reno Field Station Supervisor, to C. Gertz, Yucca Mountain Project Manager, February 9, 1990). Survival of adult desert tortoises was very high during the study, and no effects of site characterization activities were detected on adult survival or the other response variables measured. The power of most statistical tests was low at the relatively small effect sizes observed; however, power to detect moderate or large effects, had they occurred, would have been relatively high for six of the eight response variables evaluated. It was concluded that the Yucca Mountain Site Characterization Project had no detectable negative effect on the desert tortoise population at Yucca Mountain during 1992 through 1995. (Authors) *Keywords:* YMSCO*, management*, perturbations*, desert tortoise*, ecology/ecosystem*, life history*

546 RAUTENSTRAUCH, K.R., D.L. RAKESTRAW, G.A. BROWN, J.L. BOONE, and A.L. HUGHES. 1997. Patterns of Burrow Use by Desert Tortoises at Yucca Mountain, Nevada. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00041 Rev 00. Las Vegas, NV, 21 pp.

Burrows are an important habitat resource for desert tortoises. They provide protection from predators and are the location where many social interactions take place and where females often lay eggs. Most important, they provide refuge from extreme temperatures and therefore are a key component of the behavioral thermoregulatory strategy of desert tortoises. One hundred thirteen adult desert tortoises were radiomarked and subsequently located 17,922 times during 1992 through 1994 to quantify the seasonal patterns of cover type use and to determine the number and types of burrows used by desert tortoises at Yucca Mountain, Nevada. As expected, the annual pattern of burrow use was closely related to temperatures. Tortoises were located in burrows more than other types of cover during the hottest and coldest months, and were most often found in aboveground pallets and away from cover during months with more moderate temperatures. Tortoises at Yucca Mountain used an average of about 12 burrows per year. This is more than has been reported elsewhere for desert tortoises, although different methodologies make direct comparisons difficult. The number of burrows used was quite variable and ranged from 4 to 23. An average of 39 and 27% of the burrows used per year by males and females, respectively, were deep (>1 m in length). Tortoises also used an average of about five new burrows per year, which was an average of 39-52% of the burrows they used each year. Most of the new burrows (80%) were shallow (<1 m in length), suggesting that there is a relatively high turnover of burrows, especially shallow burrows. Males and females differed considerably in their use of burrows and other types of cover. Annually, males were observed in deep burrows more often than females. Males also used more deep burrows than females. Differences in seasonal patterns between sexes were associated with differences in reproductive activities. During spring, females were in shallow burrows and away from cover more than males. They also used more burrows than males during spring. This season coincides with egg laying, and females may have been moving between burrows frequently to obtain resources for egg production and to search for nest sites. During fall, males used more burrows and were found away from cover more often than females, probably because males were moving between burrows during fall seeking females with which to mate. Differences among years were not as clearly defined. On an annual basis, tortoises used more burrows during 1992 than 1994, and use of pallets and shallow burrows differed between 1992 and 1993. Seasonally, tortoises were more likely to have been in pallets during summer 1992 and less likely to have been pallets during summer 1994. In addition, they were in deep burrows more often than expected during spring 1992. Some of these differences can be explained by differences among years in precipitation, temperature, and timing of hibernation. (Authors) *Keywords*: YMSCO*, desert tortoise*, ecology/ecosystem*

547 **RAUTENSTRAUCH, K.R., M.K. COX, T.B. DOERR, R.A. GREEN, J.M. MUELLER, T.P. O'FARRELL, and D.L. RAKESTRAW. 1991. Management and Research of Desert Tortoises for the Yucca Mountain Project. In: High Level Radioactive Waste Management, Proceedings of the Second Annual International Conference, Las Vegas, NV, April 28 to May 3, 1991. American Nuclear Society, La Grange, IL, pp. 1449-1455.**

A program has been developed for the Yucca Mountain Project (YMP) to manage and study the desert tortoise (*Gopherus agassizi*), a threatened species that occurs at low densities at Yucca Mountain. The goals of this program are to better understand the biology and status of the desert tortoise population at Yucca Mountain, assess impacts on tortoises of site characterization (SC) activities, and minimize those impacts. The first steps we took to develop this program were to compile the available information on the biology of tortoises at Yucca Mountain, ascertain what information was lacking, and identify the potential impacts on tortoises of SC. We then developed a technical design that can be used to identify and mitigate direct and cumulative impacts and provide information on tortoise biology. Interrelated studies were developed to achieve these objectives. The primary sampling unit for the impact monitoring studies is radiomarked tortoises. Three populations of tortoises will be sampled: individuals isolated from disturbances (control). Individuals near major SC activities (direct effects treatment and worst-case cumulative effects treatment), and individuals from throughout Yucca Mountain (cumulative effects treatment). Impacts will be studied by measuring and comparing survival, reproduction, movements, habitat use, health, and diet to these tortoises. A habitat quality model also will be developed and the efficacy of mitigation techniques, such as relocating tortoises, will be evaluated. (Authors) *Keywords:* YMSCO*, management*, perturbations*, desert tortoise*, ecology/ecosystem*, life history*

548 **RAVEN, P.H. 1964. *Polypogon australis* Brongn. in Nevada. Leaflets of Western Botany 10:117.**

This close relative of *P. interruptus* Kunth, reported from a wide range of localities in California and from Cedros Island, Baja California, by Rubtzoff (Leafl. West. Bot. 9:166-169, -- 1961), may now be reported from Nevada: margin of Cane Springs, drainage of French Flat, Nye Co., elev. 4,000 ft., 13 May 1959, J.C. Beatley & W. H. Rickard 556 (herb. Nevada Test Site). (Authors) *Keywords:* wetlands*, perennial plants*, taxonomy*

549 **REED, J.W. 1969. Climatology of airblast propagations from Nevada Test Site nuclear airbursts. USAEC Report SC-RR-69-572, 123 pp.**

Microbarograph data from Nevada atmospheric nuclear tests of 1951 to 1962 have been assembled to show climatological patterns for long range propagations. Amplitudes have been normalized to 1-kiloton yield, free-airburst, after actual height-of-burst effects were removed. On-site propagations under early morning inversions often showed double the amplitudes expected for standard hemispherical wave expansion. These enhanced blasts were blocked by mountains and did not penetrate off-site. Strong winds at higher altitudes gave as much as 5x blast magnifications at Indian Springs and Las Vegas. Ducting at very high altitude, to 30 miles or 150,000 feet, is seasonally directed eastward in winter, westward in summer. Resulting amplitudes in the sound ring near 135 miles range show as large as 3x magnification downwind and 0.006x reduction upwind. On the average the annual cycling in east and west directions ranges from near standard, lx downwind amplitudes to 0.016x upwind amplitudes. The seasonal reversal periods when upper winds are nearly calm, occur about May 5 and September 20. At that time amplitudes in all directions show an average 0.28x reduction below standard. (Author) *Keywords:* climate*, radionuclide inventory*

550 **RESOURCE CONCEPTS, INC. 1989. Review of revegetation practices appropriate for reclamation of the proposed nuclear waste repository at Yucca Mountain, Nevada. NWPO-EV-002-89, Resource Concepts, Inc., Carson City, NV, 43 pp.**

The Yucca Mountain site, proposed by US Department of Energy (DOE) as the nation's first high-level radioactive waste repository is located in Nye County, Nevada, approximately 100 miles northwest of Las Vegas. Yucca Mountain is located in a botanically unique transition zone between the Great Basin and the Mojave Desert. The environment of the proposed repository is influenced by both biotic provinces, and additionally possesses characteristics that are unique unto itself. The purpose of this report is to summarize the existing pertinent data relative to the local environmental constraints that affect reclamation; describe the observations that have been made regarding vegetation reestablishment in the absence of reclamation; and provide special horticultural considerations appropriate for harsh environments such as Yucca Mountain. Further, this report provides specific recommendations to acquire further more specific information needed to refine reclamation prescriptions specifically for Yucca Mountain. Finally, this report describes the time and procedural commitment that must be made to monitor reclamation success. 43 refs., 1 tab. (Authors) *Keywords:* YMSCO*, perturbations*, vegetation*, ecology/ecosystem*, revegetation*

551 **REVEAL, J.L. 1968. Anew variety of *Eriogonum umbellatum* from southern Nevada. Great Basin Naturalist 28:157-159.**

Erigonum umbellatum Torrey var. *vernum* Reveal, new variety, is described from the Nevada Test Site, southern Nevada, USA. The new variety, as the name implies, flowers in the spring of the year from May to early June. Likewise, none of the southern Nevada varieties has flowers as long as those found in var. *vernum*. Morphologically, it is compared with varieties *umbellatum*, *subaridum*, *polyanthum*, and *speciosum*. Of the various taxa in the species, the var. *vernum* is probably most closely related to var. *dichrocephalum*. (RS) *Keywords:* perennial plants*, taxonomy*

552 **REVEAL, J.L. 1969. New species in *Eriogonum* and *Gilia* from southern Nevada. Bull. Torrey Bot. Club 96:476-484.**

A new species of *Eriogonum* (Polygonaceae) is described as *E. concinnum* from the Nevada Test Site and the adjacent Las Vegas Bombing and Gunnery Range in Nye County. A member of the subgenus *Ganysma*, the new species is most closely related to E. *esmeraldense* and *E. rubricaule*. The new *Gilia* is a member of the subgenus *Giliandra*, and most closely related to *G. hutchinsiifolia*. Named *G. nyensis*, the new species ranges from central Nye County southward to the Nevada Test Site. (TPO) *Keywords:* perennial plants*, taxonomy*

553 **REVEAL, J.L. 1971. A new *Frasera* from southern Nevada (Gentianaceae). Bull. Torrey Bot. Club 98:197-108.**

Frasera pahutensis sp. nov. is described from Pahute Mesa, Nye Co., Nevada on the Nevada Test Site. It is easily distinguished from all other species in the genus, and in particular from *F. puberulenta*, by its numerous stems, short inflorescences, greenish-white corollas, narrowly oblong glands with a cover only at the very base, and small crown scales. *Keywords:* perennial plants*, taxonomy*

554 **REVEAL, J.L., and J.C. BEATLEY. 1974. A new variety of *Penstemon thurberi* (Scrophulariaceae). Great Basin Naturalist 34:230.**

Penstemon thurberi Torr. var. *anestius* Reveal & Beatley, a new variety of *Penstemon* is described from material collected east of Frenchman Flat dry lake. It differs from var. *thurberi* in the smaller and less obvious flowers. (TPO) *Keywords:* perennial plants*, taxonomy*

555 **RHOADS, W.A. 1974. Analysis of Vegetation Cover in Certain Pu-Contaminated Areas Using Aerial Photography. In: *The Dynamics of Plutonium in Desert Environments*. Dunaway, P.B., and M.G. White (Eds.). NVO-142, U.S. Atomic Energy Commission Nevada Operations Office, Las Vegas, NV, pp. 119-133.**

Two methods of estimating vegetation cover were developed using aerial photographs; both are less expensive and do not contribute to disturbance of the areas compared to standard methods of measuring vegetation cover on the ground. Cover values for five Pu-contaminated areas at Nevada Test Site and Tonopah Test Range are presented. (Author) *Keywords:* NAEG*, vegetation*, ecology/ecosystem*, methods*

556 **RHOADS, W.A. 1975. Effects of fallout radiation on vegetation from venting of an underground nuclear detonation. USAEC Report EGG 565-117, 30 pp.**

The accidental venting of radioactive material from Project Baneberry, an underground nuclear explosion, resulted in the irradiation of the native shrubs about 1.5 km to the north with doses estimated to reach 6248 rads beta plus gamma irradiation exposure. At the highest doses 35 percent of the dominant shrub in the area, *Coleogyne* (black brush), were killed and 65 percent severely damaged. At doses of 400 to 800 rads there was moderate damage. Other species of shrubs were also affected. *Grayia* showed a low frequency of stem fasciation at the higher doses as well as other manifestations of radiation damage. Although no firm conclusion as to causality could be made about effects on annual species which were seeds or very small seedlings when irradiated, there were more areas without annual species at the higher radiation levels than at the lower. At the same time there was a greater frequency of higher dry weights produced by the annual species at the higher radiation exposures. These conditions were attributed to the probability of greater lethality from radiation doses to seeds to seedlings of the annual species in the open; that is, away from the protection of the shrub clumps. At the same time the annuals, which were under shrub clumps where the shrubs themselves often were killed, had greater moisture and nutrients available to them, and this resulted in greater productivity and greater frequency of dry weights of annual plant material in areas with higher exposure doses. (Author) *Keywords:* annual plants*, perennial plants*, radiation*

557 **RHOADS, W.A. 1976. Analysis of Vegetation Cover in Certain Plutonium-Contaminated Areas Using Aerial Photography. In: *Nevada Applied Ecology Group Procedures Handbook for Environmental Transuranics*. White, M.G., and P.B. Dunaway (Eds.). NVO-166, U.S. Energy Research and Development Administration Nevada Operations Office, Las Vegas, NV, pp. 283-293.**

Two methods of estimating vegetation cover were developed using aerial photographs; both are less expensive and do not contribute to disturbance of the areas compared to standard methods of measuring vegetation cover on the ground. Cover values for five Pu-contaminated areas at Nevada Test Site and Tonopah Test Range are presented. (Author) *Keywords:* NAEG*, vegetation*, ecology/ecosystem*, methods*

558 **RHOADS, W.A. 1976. Ground Motion Effects of Underground Nuclear Testing on Perennial Vegetation at the Nevada Test Site. EGG-1183-2317. Las Vegas, NV, 62 pp. DOE/NV Accession #NV0083125.**

In this study to estimate the potential injury to vegetation from earth movement caused by underground nuclear detonations and to estimate the extent to which this may have occurred at NTS, two explosions in the megaton range on Pahute Mesa were studied in some detail: Boxcar which caused a surface subsidence and Benham which did not. Because of the subsidence phenomenology, shock propagation through the earth and along the surface, and the resulting fractures, shrubs were killed at Boxcar around the perimeter of the subsidence crater. Both trees and shrubs were killed along tectonic faults, which became the path for earth fractures, and along fractures and rock falls elsewhere. There was also evidence at Boxcar of tree damage which antedated the nuclear testing program, presumably from natural earthquakes. With the possible exception of damage to aged junipers this investigation did not reveal any good evidence of immediate effects from underground testing on vegetation beyond that recognized earlier as the edge effect. Rainier Mesa, the site of 24 underground detonations announced between 1957 and May 1970, has dead trees, particularly where surfaces are steep and subject to slipping and falling from explosion-generated earth movements. However, a 1974 resurvey of a study plot initially surveyed in 1964 did not indicate changes in vegetation attributable to the effects of underground testing. This suggested that if effects are not manifested within a year for shrubs and 3 to 5 years for trees (estimated times), then damage is not likely to be observed at all. A worst-case analysis of a 3-km radius around Boxcar, which also included a second large underground explosion, suggested that the extent of damage is within the range of that vegetation removed in road building and other engineering requirements needed to carry out the underground experiments. Of the dominant species studied in the area, *Artemisia*, the most abundant shrub genus on Pahute and Rainier Mesas, appeared least susceptible to damage. Earth movement, surface acceleration, tension, shock, and shaking of the earth alone does not kill *Artemisia*; there must also be obvious surface disruption. Juniper trees were more likely to be damaged at either or both their roots and branches. Branches are particularly susceptible among mature and aged trees. Some evidence indicated that the arborescent shrub *Cowania* was more susceptible than either of these other species. (Author) *Keywords:* perturbations*, perennial plants*

559 **RHOADS, W.A. 1977. The Status of Annual Plant Species In The Baneberry Fallout Pattern -- First and Sixth Years After Initial Irradiation. In: *Transuranics in Desert Ecosystems*. White, M.G., and P.B. Dunaway (Eds.). NVO-181, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 53-79.**

At Project Baneberry on December 18, 1970, there was an accidental venting of radioactive debris into the environment which resulted in the irradiation of vegetation about 1.5 km to the north with doses estimated to reach a maximum of 6.2 K rads, beta plus gamma. At the highest doses, 35 percent of the dominant shrub in the area, *Coleogyne* (black brush), were killed and 65 percent severely damaged; and at lesser doses there was correspondingly less damage. Other species of shrubs were also affected. *Grayia spinosa* showed a low frequency of stem fasciation at higher doses as well as other manifestations of radiation damage. In June 1971, the annual plant species which were probably small seedlings at fallout time were more frequently absent from the higher radiation areas than in the lower. At the same time, there was a greater frequency of higher dry weights produced by annuals at the higher radiation exposures. The frequency of occurrence of annuals varied from means of 8.5/m^2 at the higher doses to 24.3/m^2 at the lower doses. In June 1976, five years after irradiation, there were 300-400 plants/m^2. (Precipitation for those years was approximately the same.) By extrapolating the plants/m^2 against dose back to zero plants/m^2, some indication of radiation doses which might destroy all annuals was derived. With the number of annuals/m^2 in 1971 expressed as percentages of those in 1976, another extrapolation to zero plants/m^2 suggested still another but similar dose (both in the range of 12-20 K rads, beta-gamma) for destruction of all annuals. These values are tentative, and only provide a basis for better estimates as to what such a dose might be in the environment with its many variables of which only a few are adequately understood. (Author) *Keywords:* NAEG*, annual plants*, perennial plants*, radiation*

560 RHOADS, W.A. 1978. Vegetation Damage in Sedan and Baneberry fallout Patterns - A Retrospective Comparison. In: *Selected Environmental Plutonium Research Reports of the NAEG*. White, M.G., and P.B. Dunaway (Eds.). NVO-192 Volume 1, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 127-141.

Completion of the study of radioactive fallout effects from Project Baneberry prompted a reconsideration of earlier reports of effects of an underground nuclear excavation experiment nearby, i.e., the Sedan cratering experiment of 1962. Although it was concluded that radiation exposures did not kill either annual plant species or shrub species, a reexamination of the published data suggests that in the second year after Sedan, there was a reduction in numbers of annual plants/m^2 which could be attributed to ionizing radiation. On the bases of projection of results at Baneberry, on probable exposure doses at Sedan, and on species' theoretical radiation sensitivities, the absence of annual species the first year after Sedan could be attributed to ionizing radiation. Similarly, the radiation doses reported were, in retrospect, sufficient to have accounted for damage to shrubs. Observations since that time on dust effects alone have not given any evidence of the lethality of nonradioactive dust. In short, there is good evidence of radiation damage to both annual and perennial vegetation at Sedan like that at Baneberry, despite published conclusions to the contrary. (Author) *Keywords:* NAEG*, perturbations*, perennial plants*, annual plants*, radiation*

561 RHOADS, W.A., and L.A. FRANKS. 1975. Radiation Doses and Possible Radiation Effects of Low-Level, Chronic Radiation in Vegetation. In: *The Radioecology of Plutonium and Other Transuranics in Desert Environments.* White, M.G., and P.B. Dunaway (Eds.). NVO-153, U.S. Energy Research & Development Administration Nevada Operations Office, Las Vegas, NV, pp. 89-95.

An area around Site D, Area 11, was chosen for measurement of radiation doses with the objective of investigating low-level, low-energy gamma radiation (with some beta radiation) effects at the cytological or morphological level in native shrubs. In this preliminary investigation, the exposure doses to shrubs at the approximate height of stem apical meristems were estimated from 35 to 140 R for a ten-year period. The gamma exposure dose estimated for the same period was 20.7% to 6.4% of that recorded by the dosimeters used in several kinds of field instrument surveys. Hence, a survey instrument reading made at about 25 cm in the tops of shrubs should indicate about 1/5 the dosimeter-measured exposures. No cytology has yet been undertaken because of the drought since last winter. (Authors) *Keywords:* NAEG*, perennial plants*, radiation*

562 RHOADS, W. A., and R.B. PLATT. 1971. Beta radiation damage to vegetation from close-in fallout from two nuclear detonations. BioScience 21:1121-1125.

The report recounts first field experiments associated with nuclear events and concerned with vegetation damage attributed primarily to beta radiation. It is supported by the first extensive field dosimetry for measuring both beta and gamma radiation doses simultaneously. Two small nuclear cratering experiments, Palanquin on April 14, 1965 and Cabriolet on January 26, 1968 occurred at the Nevada Test Site. Vegetation studies were made on two species of sagebrush, *Artemisia arbuscula* and *Artemisia tridentata*. Downwind to Palanquin, shrubs and trees were killed over an area of more than 3 km^2, and in Cabriolet they were killed over a few hundred square meters beyond the area covered by material thrown from the crater. At Palanquin, the killed and damaged areas coincided with areas of elevated radiation backgrounds. Doses at Cabriolet were documented with special dosimetry to measure the field of beta doses in the presence of gamma radiation. Conclusions were drawn that damage and death of *Artemisia* downwind to Palanquin and Cabriolet were attributable to fallout radiation, and beta radiation, with its large potential doses, was primarily responsible. (BBM) *Keywords:* perennial plants*, radiation*

563 RHOADS, W.A., and H.L. RAGSDALE. 1973. *Artemisia* shrub size and radiation damage to *Artemisia* from local fallout

from Project Schooner. In: (Nelson, D.J., Ed.) *Radionuclides in Ecosystems,* Proceedings of the Third National Symposium on Radioecology (CONF-710501), pp. 953-960.

Project Schooner was a nuclear cratering experiment in the Plowshare Program for peaceful applications of nuclear explosives. The 31 kt device produced a crater about 260 meters across and 63 meters deep on Pahute Mesa in the northeast corner of the Nevada Test Site. At distances of 1.7 kilometers the accumulated γ doses on dosimeters removed from the field 12 days post-event ranged from background to more than 900 rads; the β doses reached maximums of 10,650 rads. At these highest doses all *Artemisia* shrubs were killed. At dosimeter stations with less than total mortality, samples of 100 shrubs were measured, and estimates were made of the extent of their damage. Analysis of these data showed that shrubs with smaller volumes were more likely to be killed or severely damaged than were larger shrubs. The results are in accord with conclusions that shrub damage in local fallout patterns is primarily attributable to g radiation. The diminution of B doses by air shielding and shrub self-shielding protects larger shrubs more than the smaller ones. (Authors) *Keywords:* perennial plants*, radiation*

564 RHOADS, W.A., and D.M. VARNEY. 1977. Investigation of Possible Cytological Effects on Shrubs From Chronic Low-Level Radiation at NTS (Progress Report). In: *Environmental Plutonium on the Nevada Test Site and Environs.* White, M.G., P.B. Dunaway, and W.A. Howard (Eds.). NVO-171, Nevada Applied Ecology Group, U.S. Energy Research & Development Administration, Las Vegas, NV, pp. 111-119.

Evidence of radiation damage to vegetation at NTS has been found only at the morphological or phenological levels and in the vicinity of nuclear cratering experiments, or in fallout patterns of accidental ventings of radioactive debris. Some effects have been noted in controlled experiments around large gamma radiation sources, also. Possible effects at the cytological level at lower radiation doses are also of interest. Because there have been annual species which have been irradiated in all stages of their life cycles for a number of generations, these species are of special interest; however, unfavorable precipitation did not produce sufficient annuals in either 1974 or 1975 for examination. Shrub species are also of interest, and one shrub, *Artemisia spinescens,* was found to have cells at the proper stage for examination (chromosomes number after meiosis equal nine). At Site D, Area 11, irradiated since 1954-1955 to estimated doses of 35 to 140 R, 5 percent of the cells producing pollen were aberrant compared with 1.7 percent of the cells from plants outside the irradiated area. Because of the small numbers of cells examined, these numbers were not, however, considered adequate to provide more than an indication that there were more aberrants in the irradiated areas than in the nonirradiated. (Authors) *Keywords:* NAEG*, perennial plants*, radiation*

565 RHOADS, W.A., and M.P. WILLIAMS. 1977. Status of Endangered and Threatened Plant Species on Nevada Test Site - A Survey. Part 1: Endangered Species. EG&G Energy Measurements, Santa Barbara Operations Report No. EGG 1183-2356.

Eight species which occur on NTS and one which occurs just outside the west boundary have been suggested by the Fish and Wildlife Service (FWS) as endangered plants in Nevada under the Endangered Species Act of 1973. This survey provides a basis for suggesting that seven of the nine species remain as candidates for the endangered status, and that two be removed to the threatened status. The following species are recommended for the endangered status: *Astragalus beatleyae, Astragalus nyensis, Lathyrus hitchcockianus, Trifolium andersonii ssp. beatleyae, Frasera pahutensis, Phacelia beatleyae, Camissonia megalantha.* The two recommended for the threatened status are *Penstemon pahutensis* and *Arctomecon merriamii*. In addition we suggest that two species not previously listed for Nevada by FWS be considered as endangered. These are *Phacelia parishii,* found this summer for the first time since 1941 on NTS, and *Galium hilendiae ssp. kingstonense*, previously listed as a candidate for endangered status for California but not for Nevada. We also suggest two species for the Similarity of Appearance Status (S/A) when these occur within the critical habitats of the endangered species candidates they closely resemble; these are *Astragalus acutirostris* which closely resembles *A. nyensis*, and *C. heterochroma* which closely resembles *C. megalantha*. (WKO) *Keywords:* sensitive plants*, ecology/ecosystem*

566 RHOADS, W.A., S.A. COCHRANE, and M.P. WILLIAMS. 1977. Status of Endangered and Threatened Plant Species on Nevada Test Site - A Survey. Part II: Threatened Species. EG&G Energy Measurements, Santa Barbara Operations Report No. EGG 1183-2356, Part 2.

Among the 15 plant species that grow on NTS and appeared in the Federal Register lists of candidate threatened species we report three*: Astragalus funereus*, *Coryphantha vivipara* var. *Rosea*, and *Gilia ripleyi*, that should be considered as threatened. Two other species which occur on NTS and were not included on either the threatened or endangered lists should also be classified as threatened: *Penstemon thurberi* var. *aestivus* and *Sclerocactus polyancistrus*. Of the 12 other species originally listed in the Federal Register, eight are of sufficient interest to warrant continued monitoring. The other four do not appear to require any protective measures or surveillance. We suggest critical habitats for those species recommended for threatened status. (Authors/WKO) *Keywords:* sensitive plants*, ecology/ecosystem*

567 **RHOADS, W.A., S.A. COCHRANE, and M.P. WILLIAMS. 1979. Addendum to Status of Endangered and Threatened Plant Species on Nevada Test Site - A Survey. Parts 1 and 2. EG&G Energy Measurements, Santa Barbara Operations Report No. EGG 1183-2356.**

This addendum revised and updated the previous reports. New information and field data concerning distribution and population densities of endangered and threatened species were collected during 1978. A summarization of past and present opinions on status held by different groups and agencies and the current REVD-T ratings was presented for each species. *Phacelia parishii, Phacelia beatleyae, Frasera pahutensis, Lathyrus hitchcockianus,* and *Camissonia megalantha* were recommended for removal from endangered status. *Penstemon thurberi* var. *Aestivus* warrants endangered rather than threatened status. (Authors) *Keywords:* sensitive plants*, ecology/ecosystem*

568 **RHOADS, W.A., S.A. COCHRANE, and M.P. WILLIAMS. 1979. Status of Endangered and Threatened Plant Species on Tonopah Test Range - A Survey. EG&G Energy Measurements, Santa Barbara Operations Report No. EGG 1183-2387.**

Construction activities and off-road vehicles were the most important man-caused threats to plant species on TTR, but habitat destruction by trampling and overgrazing by feral horses and non-permit cattle were significant causes of modification of habitats of certain species. (Authors) *Keywords:* perturbations*, sensitive plants*, ecology/ecosystem*

569 **RHOADS, W.A., A.D. KANTZ, and H.L. RAGSDALE. 1972. Ecological and environmental effects from local fallout from Schooner. 2. The beta and gamma radiation effects from close-in fallout. USAEC Report PNE-529, 41 pp.**

Project Schooner, a nuclear cratering event with approximately eight to ten times the yield of two previous Nevada Test Site cratering events, Palanquin and Cabriolet, offered the opportunity to further investigate radiation dose and short-term effects to vegetation and the environment, where a larger affected area was anticipated and where topography might be expected to further influence the results of close-in fallout. Specially constructed dosimeters were placed at 92 locations, forming an arc with a radius of approximately 1.7 to 2.0 km. Dosimeters were positioned in vertical arrays at 25 cm, 1 meter, and 3 meters above the surface away from shrubs, as well as on the soil surface, and on shrubs. To determine whether preventing direct fallout from reaching the shrubs would protect them, polyethylene sheets were placed over shrubs at alternate stations. Twelve days after detonation the dosimeters were removed from the field and the protective sheets were removed. No effects were observed on the vegetation except a dusty covering on the unprotected shrubs. In April (D plus 4 months) the first effects attributable to radiation were noted. During the following months at the center of the fallout pattern all *Artemisia* shrubs lost their leaves and died except those which had been covered with plastic sheets. Elsewhere along the arc there was a "skirting effect" in which the lower parts of larger shrubs were defoliated while the tops remained near normal. Small shrubs were completely killed. Increasingly larger shrubs were killed with higher doses. Beyond the dosimetry arc, a helicopter survey allowed an assessment of the extent of vegetation damage. South of the crater, study sites were established in the most diverse environments resulting from the crater formation. Vegetation analysis at these sites showed successional changes which might be expected to return the area to conditions approximating undisturbed conditions. (Authors) *Keywords:* perturbations*, perennial plants*, radiation*

570 **RHOADS, W.A., R.B. PLATT, and R.A. HARVEY. 1969. Radiosensitivity of certain perennial shrub species based on a study of the nuclear excavation experiment, Palanquin, with other observations of effects on the vegetation. USAEC Report CEX-68.4, 42 pp.**

Comparison was made between the sensitivities of certain species of plants from the higher elevations of the Nevada Test Site to gamma radiation from a ^{60}Co source and from conditions in the fallout pattern of the nuclear excavation experiment Palanquin. *Artemisia*, sagebrush, appeared much more sensitive to fallout, based on the infinite dose it received, than the radiation dose from pure gamma from ^{60}Co indicated it ought. The proposal was made that beta radiation contributed a greater dose to *Artemisia* than to certain other species because of its particular foliar retentive capacity for fallout particles. This suggested that beta radiation may be an important component in considering damage to vegetation from fallout, since other factors known to have damaged vegetation in nuclear experiments could, for the most part, be eliminated. (Authors)

Keywords: perennial plants*, radiation*

571 **RHOADS, W.A., R.B. PLATT, R.A. HARVEY, and E.M. ROMNEY. 1969. Ecological and environmental effects from local fallout from Cabriolet. 1. Radiation doses and short-term effects on the vegetation from close-in fallout. USAEC Report PNE-956, 65 pp.**

An intensive dosimetry experiment was undertaken on the vegetation in the vicinity of the proposed ground zero for the underground Cabriolet detonation. The midline of the fallout pattern occurred near the western edge of an arc of dosimeters placed 610 meters from ground zero: the highest measured gamma dose was 800 rad. The highest beta dose was about 8,000 rad yielding a beta-to-gamma ratio of 10, but the ratio varied around 4 to more than 12. Four months postdetonation the vegetation demonstrated changes previously associated with radiation damage, and some species eventually died. It was concluded that beta radiation was primarily responsible for the observed damage as the total doses were near the previously established doses required to damage and kill the vegetation being considered. (TPO) *Keywords:* perennial plants*, radiation*

572 **RHOADS, W.A., H.L. RAGSDALE, R.B. PLATT, and E.M. ROMNEY. 1971. Radiation doses to vegetation from close-in fallout at Project Schooner. In: (Bensen, D.W., and A. H. Sparrow, Eds.) *Survival of Food Crops and Livestock in the Event of Nuclear War,* AEC Symposium Series 24 (CONF-700909), pp. 352-369.**

Project Schooner was a nuclear cratering experiment in the Plowshare Program for peaceful application of nuclear explosives. On the basis of information from two earlier experiments, Palanquin and Cabriolet, special dosimeters for measuring both beta and gamma radiation were placed in the open environment and on shrubs in the downwind area where fallout was anticipated. In addition, polyethylene sheets were placed over some shrubs to determine whether the shrubs could thus be protected against radiation damage. The gamma radiation doses for shrubs not covered were found to be essentially the same as the doses measured in the open and away from shrubs, but there was a 15 percent reduction in dose under the sheets. The beta doses to unsheltered vegetation were, however, reduced by almost 50 percent compared with doses at 25 cm in the open. This reduction was attributed to self-shielding. Beta doses to the shrubs were reduced still further, to 11 percent of the 25-cm beta dose in the open, by shielding the shrubs from direct fallout contamination. The estimated LD50 for *Artemisia* was 4449 rads, but the reduction in doses by the shelters was nearly sufficient to prevent damage to the shrubs, even though all other *Artemisia* shrubs in the center of the fallout pattern were killed. It was concluded that beta doses must be considered in protecting growing food crops and livestock and that even minimal shelter to prevent direct surface contamination would be of great importance. (Authors) *Keywords:* perennial plants*, radiation*

573 **RICHARDS, G. 1962. Wintering habits of some birds at the Nevada atomic test site. Great Basin Naturalist Memoirs 22:30-31.**

Describes species composition and relative abundance of birds observed wintering in undisturbed habitats of the Nevada Test Site, as well as other locations that were drastically altered by nuclear weapons testing. The alien winter annual forb, *Salsola kali*, invaded disturbed sites and appeared to provide winter feed for birds that was in excess of that provided

by undisturbed vegetation associations. (TPO) *Keywords:* perturbations*, invasive species*, annual plants*, bird*, nutrition/diet*, ecology/ecosystem*

574 **RICHARDS, G.L. 1965. Prairie falcon imitates flight pattern of the loggerhead shrike. Great Basin Naturalist Memoirs 25:48.**

Prairie falcons were observed imitating the undulating flight patterns of loggerhead shrikes to approach unsuspecting white-tailed antelope ground squirrels. (TPO) *Keywords:* bird*, life history*, ecology/ecosystem*

575 **RICKARD, W.H. 1960. Gross Vegetation Patterns Within the Nevada Test Site. The Colorado-Wyoming Academy of Science 4:3.**

Frenchman Flat and Yucca Flat each support four major intergrading shrub zones. In both flats these vegetation belts are more or less concentrically arranged, extending from a playa at the lowest point in the southeast quarter to the foot of the interbasin mountains. In Frenchman Flat *Atriplex canescens*, mixed with *Franseria dumosa*, extends on silt-like soil out for one to several miles from the playa margin. An adjacent belt of *Lycium andersonii* reaches one to several miles farther on light sandy soil. Beyond this zone, *Larrea divaricata* dominates an extensive pattern of shrubs extending to near the higher valley margins. *Larrea and Franseria*, which constitute the bulk of the vegetative cover in Frenchman Flat, are southern desert forms. *Coleogyne ramosissima*, a transitional species, occurs as a narrow fringe on the higher, stony valley margins. Across Yucca Pass, forested on the north slopes by *Yucca brevifolia*, the southern desert species are replaced by transitional forms which at the northern end of Yucca Flat converge upon the northern desert species, *Artemisia* in particular. In Yucca Flat the *Atriplex-Kochia* vegetation zone marginal to the playa overlaps with *Atriplex confertifolia-Eurotia lanata*. A third belt, dominated by *Grayia spinosa* extends from within four miles of the playa laterally to near the valley margins and northward for more than 20 miles, meeting *Coleogyne ramosissima* within three miles of the mesa in the northwest corner of the test site. In Jackass Flat, *Larrea divaricata* covers much of the extensive alluvial fill, dominating 13 or 15 plots. (Authors) *Keywords*: vegetation*, perennial plants*, ecology/ecosystem*

576 RICKARD, W.H. 1961. Notes on bird nests found in a desert shrub community following nuclear detonations. Condor 63:265-266.

The occurrences of bird nests in relation to the gross influences of nuclear detonations, which occurred prior to September 2, 1957, on the vegetation of a desert shrub community are reported. (MCG) *Keywords:* perturbations*, vegetation*, bird*, ecology/ecosystem*, radiation*

577 RICKARD, W.H. 1962. Phytosociological analyses in a desert shrub community following atomic explosions. USAEC Report HW-SA-2546, 7 pp.

Quantitative and qualitative changes were recorded in the annual vegetation when phytosociological comparisons were conducted between adjacent disturbed and undisturbed plant communities two and three years after the last occurrence of atomic explosions in target area 4, Yucca Flat, Nevada. (Author) *Keywords:* perturbations*, annual plants*, ecology/ecosystem*, radiation*

578 RICKARD, W.H. 1963. Vegetational analyses in a creosote bush community and their radioecologic implications. In: (Schultz, V., and A.W. Klement, Jr., Eds.) *Radioecology*, Proceedings of the First National Symposium on Radioecology, pp. 39-44.

Detailed vegetation analyses were conducted on fifteen permanent plots in a creosote bush (*Larrea divaricata*) community surrounding the nuclear reactor facilities. Creosote bush dominated the canopy-coverage provided by 11 shrub species and two species of bunch grasses by contributing 6.1 percent of the total 13.7 percent ground cover. *Chaenactis stevioides* dominated the herbaceous understory vegetation. The amount of ground covered by vegetative canopies, the contribution of each species to ground cover, and development and seasonal persistence of understory layers and the phenological sequence of leaf development and abscission are believed directly related to vegetative retention of radioactive fallout by desert shrub communities. (HP) *Keywords:* annual plants*, perennial plants*, ecology/ecosystem*, life history*, radiation*

579 RICKARD, W.H., and J.C. BEATLEY. 1965. Canopy-coverage of the desert shrub vegetation mosaic of the Nevada Test Site. Ecology 46: 524-529.

Canopy-coverage of shrubs and perennial herbs was determined by 44 relatively undisturbed sites scattered throughout the vegetation mosaic covering several valleys in southcentral Nevada. The dominant shrubs were *Larrea divaricata, Grayia spinosa, Lycium andersonii, Coleogyne ramosissima, Atriplex confertifotia, Artemisia tridentata*, and *A. arbuscula* subsp. *nova*. Perennial herbs contributed little to canopy-coverage. The perennial herbs most frequently encountered were *Oryzopsis hymenoides* and *Stipa speciosa*. In the spring of 1960, on 34 of the same sites, the canopy-cover of annual herbs was also determined. Sites dominated by *Larrea* shrubs had more annual species and also the greatest amount of annual cover. *Chaenactis stevioides* was ubiquitous and often the dominant annual encountered throughout the vegetation mosaic. Other important annuals were *Mentzelia veatchiana, Eriogonum maculatum, Eriophyllum pringelei, Bromus rubens, Cryptantha nevadensis, C. circumscissa*, and *Amsinckia tesselata*. (Authors) Keywords: invasive species*, annual plants*, perennial plants*, ecology/ecosystem*

580 RICKARD, W.H., and J.R. MURDOCK. 1963. Soil moisture and temperature survey of a desert vegetation mosaic.

Ecology 44:821-824.

From March 4 to May 9, 1960 soil temperature and moisture measurements were made in 7 plant habitats on the Nevada Test Site, Nye County, Nevada. Soil moisture was determined by gravimetric sampling, and temperatures were measured using the sucrose inversion technique. Cooler soil temperatures were not always associated with an increase in elevation. In some cases topographic positions and soil properties influenced soil temperatures and available soil moisture more strongly than did elevational changes. (Authors) *Keywords:* soil property*, vegetation*, methods*

581 **RICKARD, W.H., and L.M. SHIELDS. 1963. An early stage in the plant recolonization of a nuclear target area. Radiation Botany 3:41-44.**

Vegetational analyses were conducted three years post-detonation in a nuclear target area in a *Grayia spinosa-Lycium andersonii* community in Yucca Flat, Nevada. Annual plants dominated the early stage of recolonization and were quantitatively more abundant in the disturbed areas than in an adjacent undisturbed shrub community. *Mentzelia albicaulis* and *Chaenactis stevioides* occurred in both disturbed and undisturbed areas; however, *Mentzelia* was more abundant in disturbed areas while *Chaenactis* was more abundant in the undisturbed community. *Salsola kali* was confined to disturbed areas while *Phacelia vallismortae* was more often encountered in the undisturbed community. The plant recolonization of a mechanically disturbed area was quantitatively and qualitatively more like that of the interior zone of the nuclear target area than less disturbed habitats. These data support a conclusion that soil displacement presents a more rigorous habitat for plant recolonization than disturbances created by the wider ranging destructive components of a nuclear detonation. (Authors) *Keywords:* perturbations*, invasive species*, annual plants*, perennial plants*, ecology/ecosystem*, radiation*

582 **RINGELBERG, D.B., D.C. WHITE, J.O. STAIR, and L.H. HERSMAN. 1996. In Situ Characterization of the Microbiota in Yucca Mountain Sediments. In: High Level Radioactive Waste Management, Proceedings of the Seventh Annual International Conference, Las Vegas, NV, April 29 - May 3, 1996, pp. 33-35.**

A specific goal of the research being performed at the Exploratory Study Facility (ESF), Yucca Mountain, NV, is the characterization of the microbiota surrounding the high level nuclear waste repository site. (Authors) *Keywords:* YMSCO*, geology*, microbiota*, taxonomy*

583 **ROMNEY, E.M. 1976. NAEG Plutonium Program Vegetation Studies Status Report, May 1975. In: *Studies of Environmental Plutonium and Other Transuranics in Desert Ecosystems.* White, M.G., and P.B. Dunaway (Eds.). NVO-159, U.S. Energy Research & Development Administration Nevada Operations Office, Las Vegas, NV, pp. 31-34.**

This report summarizes progress for ongoing vegetation studies from 10 study areas of the Nevada Test Site including Area 13, GMX-5, Area 11, and the Roller Coaster sites at the Tonopah Test Range. Data results for four glasshouse uptake experiments are also mentioned. Existing and anticipated problems related to the field studies and future activity plans are presented. (CAW) *Keywords:* NAEG*, vegetation*, nutrition/diet*, radiation*

584 **ROMNEY, E.M., and J.J. DAVIS. 1972. Ecological aspects of plutonium dissemination in terrestrial environments. Health Physics 22: 551-557.**

The potential benefits to be derived for mankind from continued development of peaceful applications for plutonium cannot be denied. The technology of plutonium production and processing is already established, but the realization of its peaceful applications depends largely upon the development of methods for preventing its distribution in the environment. Because of safeguards and effective control measures, no accidental plutonium contamination of the public domain has imposed serious risks to a population group. Trace amounts of plutonium from above-ground nuclear detonations are contained in world-wide fallout; however, the levels of plutonium in foodstuffs and other components of the environment are insignificant compared to the amounts known to be hazardous. There has thus been very little interest in the study of ecological aspects of plutonium contamination. The result is a paucity of information on the behavior of plutonium in ecosystems and its radiological effects on natural fauna and flora. The Nevada Applied Ecology Group is embarked upon a program at the Nevada Test Site to investigate the long-range effects of plutonium disseminated into the desert ecosystem. Emphasis has been placed upon standardization of analytical methods, delineation of contaminated areas, problems of resuspension and redistribution, food chain transport, and ecological effects. (Authors) *Keywords:* NAEG*, radionuclide inventory*, vegetation*, vertebrate*, ecology/ecosystem*, nutrition/diet*, radiation*

585 **ROMNEY, E.M., and R.O. GILBERT. 1976. Standard Nevada Applied Ecology Group Procedures for Collection of Vegetation Samples From Intensive Study Areas. In: *Nevada Applied Ecology Group Procedures Handbook for Environmental Transuranics*. White, M.G., and P.B. Dunaway (Eds.). NVO-166, U.S. Energy Research and Development Administration, Nevada Operations Office, Las Vegas, NV, pp. 133-134.**

The procedures described below can be adapted to meet most field situations and sampling purposes; however, they are outlined herein specifically for the sampling of shrub vegetation in desert areas at the Nevada Test Site (NTS) known to be contaminated with plutonium. The soil and vegetation sampling programs of the Nevada Applied Ecology Group (NAEG) studies are closely integrated in order to more efficiently coordinate and correlate the subsequent radiochemical analyses and data processing phases of the work. Vegetation is a functional component of the desert environment involved in the transfer of radioactive elements from soil to grazing animals. Two different transport mechanisms are involved in the contamination of vegetation. They are: (1) uptake and concentration of radionuclides in plant parts through root systems, and (2) superficial contamination from radioactive fallout debris entrapped on the surface of plant foliage. In contaminated areas where plutonium is involved, this second mechanism appears to be the most important inasmuch as there is evidence of very low uptake of plutonium through plant roots. The needs for collecting random vegetation samples within a prescribed distance from soil sampling locations were considered in developing these procedures along with the use of sampling methods compatible with radiological safety requirements. Work in contaminated study areas is performed under supervision of NTS Rad-Safe personnel. (Authors) *Keywords:* NAEG*, vegetation*, radiation*, methods*

586 **ROMNEY, E., and P. GREGER. 1992. Wildlife Utilization of Natural Springs and Man-Made Water Sources at the Nevada Test Site. In: Status of the Flora and Fauna on the Nevada Test Site, 1988. Hunter, R.B. (Compiler), DOE/NV/10630-29, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 161-182.**

Wildlife utilization of water sources on the Nevada Test Site (NTS) had not been studied in any detail. Wildlife usage of permanent or temporary water sources was only mentioned briefly in existing studies (Hayward et al. 1963, Allred et al. 1963, Jorgensen and Hayward 1965, Giles 1976, Giles and Cooper 1985). Studies at natural springs were limited to Giles (1976), who examined the availability of water for wildlife usage; and Taylor and Giles (1979), who investigated algae living in those waters. The Giles study (1976) was the most relevant to our study, but it did not contain any detailed information on wildlife utilization over time. The long-term objectives of this study were to describe the kinds of wildlife that utilize the available water sources on the NTS, determine the extent of such utilization, and assess any changes and unusual disturbances in the natural spring habitats. (Authors) *Keywords:* wetlands*, vertebrate*, ecology/ecosystem*

587 **ROMNEY, E.M., and W.A. RHOADS. 1966. Neutron activation products from Project Sedan in plants and soils. Soil Sci. Soc. Amer. Proceedings 30:770-773.**

Neutron activation products of tungsten, scandium, and antimony were among those radionuclides concentrated through roots of plants grown on ejecta from the Sedan thermonuclear cratering detonation. Nuclear reactor-produced isotopes were used in corroborative experiments to investigate, in greater detail, their behavior in plants and soils. Radiotantalum was also included as a matter of academic interest. Plants concentrated more Sc-46, Sb-124, and W-185 in leaves than in stems, whereas Ta-182 was concentrated more in stems. Plant uptake of Sc-46, Sb-124, and W-185 was influenced by different types of soil. Scandium-46 and Ta-182 were virtually immobile in columns of soil leached with 76 cm of water while Sb-124 and W-186 moved readily in neutral and alkaline soil, but not in acidic soil. Their behavior was influenced by the kind of clay mineral present, the sodium and potassium content, and the soil pH. (Authors) *Keywords:* radionuclide inventory*, vegetation*, nutrition/diet*, radiation*

588 **ROMNEY, E.M., and A. WALLACE. 1977. Plutonium Contamination of Vegetation in Dusty Field Environments. In: *Transuranics in Natural Environments*. White, M.G., and P.B. Dunaway (Eds.). NVO-178, Nevada Applied Ecology Group, U.S. Energy Research & Development Administration, Las Vegas, NV, pp. 287-302.**

Transport of plutonium in food chains of grazing animals and mankind by vegetation carriers becomes an important avenue of contamination in dusty field environments. Findings indicate that most of the activity present in vegetation of such areas at the Nevada Test Site (NTS) is superficial contamination resulting from the attachment of particles to foliage surfaces during resuspension. We suspect, however, that the root uptake pathway eventually will become more significant as the result of natural concentration and recycling processes at work in the field within the plant root zone. (Authors) *Keywords:* NAEG*, perennial plants*, radiation*

589 ROMNEY, E.M., and A. WALLACE. 1980. Ecotonal Distribution of Salt-Tolerant Shrubs in the Northern Mojave Desert. Great Basin Naturalist Memoirs 4:134-139.

Ecotonal distribution of salt-tolerant shrubs was investigated under different kinds of edaphic conditions common to open and closed drainage basins in the northern Mojave Desert. Contributing causal factors involved changes in soil salinity, texture, and moisture stress. Varying degrees of halophytism occurred, ranging from plant species that are facultative in their adaptation to salinity to those that require comparatively high salt concentrations in soil for normal growth and development. (Authors) *Keywords:* soil property*, perennial plants*, ecology/ecosystem*

590 ROMNEY, E.M., R.B. HUNTER, and A. WALLACE. 1981. Environmental Effects of Solar Thermal Power Systems - Experiments on Restoration of Disturbed Desert Land by Means of Revegetation. UCLA 12-1312, CIC 0083260, Laboratory of Biomedical and Environmental Sciences, University of California, Los Angeles, CA.

The work effort during FY 1981 was devoted primarily to a continuation of experimental activities initiated in FY 1980 and directed toward the development of cost-effective methods of restoring native vegetation on disturbed Mojave Desert land. Emphasis has been placed upon improving techniques for producing transplanting stocks of native shrub species, investigating different ways to protect and encourage regrowth from crown and root sprouting and new seedling establishment, developing improved transplanting method, and searching for better understanding of the soil moisture requirements of new plant seedlings and transplanted shrubs. The overall project goal of vegetation management and recovery at sites disturbed for solar thermal power system installations was to develop methods of restoring native vegetation on disturbed Mojave Desert land, within a two or three year time frame, in order to provide the developers with a useful tool to help control disturbed site erosion and fugitive dust problems. In order that experimental work could be continued without interference from the STPS construction activities, some of our field plot studies have been done at the US DOE Nevada Test Site on disturbed land located in a similar Mojave Desert ecosystem. Termination of financial support necessary to continue this project beyond FY 1981 unfortunately has made the realization of the overall project goal impossible at this time. Nevertheless, some findings have been obtained over the short period this project has been underway which contribute significantly to an understanding and resolution of the problems faced in the restoration of disturbed land by means of managed revegetation. (Authors) *Keywords:* perturbations*, soil property*, perennial plants*, revegetation*, methods*

591 ROMNEY, E.M., R.B. HUNTER, and A. WALLACE. 1981. Vegetation Management and Recovery at Sites Disturbed for Solar Thermal Power - Progress Report for FY 1980. UCLA121281, Laboratory of Biomedical and Environmental Sciences, University of California, Los Angeles, CA, 25 pp.

This paper presents the primary effort of the vegetation management project during FY 1980 which was the development of cost effective methods of restoring native vegetation on disturbed Mojave Desert land. Emphasis was placed upon improving techniques for producing transplanting stocks of native shrub species, investigating different ways to protect and encourage regrowth from crown sprouting and new seedling germination, developing improved transplanting methods, and searching for more practical means of conserving seasonal soil moisture necessary for the survival of new plant seedlings and transplanted specimens. (CAW) *Keywords:* perturbations*, soil property*, perennial plants*, revegetation*

592 ROMNEY, E.M., R.B. HUNTER, and A. WALLACE. 1986. Shrub Use of Water from Simulated Rainfall in the Mojave Desert. In: Proceedings of the Rainfall Simulator Workshop January 14-15, 1985 Tucson, Arizona. Lane, L.J. (Ed.). Society for Range Management, Denver, CO, pp. 25-29.

Rainfall simulation experiments provided an opportunity to investigate the recharge of water into northern Mojave Desert soil and its subsequent use by woody shrubs after similar timing and intensity of precipitation. Applications of about 100 mm of water per treatment were made in May and September 1983, and May and October 1984. From 50 to 80 percent of the water remaining on treated plots after runoff was lost to the system by evaporation, transpiration, diffusion, etc., within the first week after simulated rainfall. From 30 to 50 percent of the water retained after runoff had recharged into the soil profile to a depth of 40-cm by one week after treatment. Shrubs growing on the treated plots experienced low moisture stress for a period of 4 to 6 weeks before the depletion of recharge water once again placed them under high moisture stress. Shrubs responded to water applied in May by extending their period of active growth for 4 to 6 weeks before undergoing summer dormancy. The growth response from water applied in September and October was masked by impact from grazing jackrabbits and burrowing pocket gophers that were attracted to the study plots. (Authors) *Keywords:* climate*, soil property*, perennial plants*, mammal*, life history*, physiology*, revegetation*

593 **ROMNEY, E.M., R.B. HUNTER, and A. WALLACE. 1987. Distribution of $^{239\text{-}240}$Pu, ^{241}Am, ^{137}Cs, and ^{90}Sr On Vegetation At Nuclear Sites 210, 219, and 220. In: The Dynamics of Transuranics and Other Radionuclides in Natural Environments (Howard, W.A., and R.G. Fuller, Eds.). U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV. NVO-272, pp. 69-78.**

Samples of vegetation were collected from close-in fallout areas at three nuclear sites and analyzed for transuranic elements and long-lived fission products 10 to 15 years after fallout was deposited. Small amounts of $^{239\text{-}240}$Pu, ^{241}Am, ^{137}Cs, and ^{90}Sr were found on the foliage of plants growing in the aged fallout areas, but the amount of a given radionuclide in the plant samples did not correlate well with the amount in the less than 2 mm fraction (<10 mesh) of corresponding soil samples. The $^{239\text{-}240}$Pu to ^{241}Am ratios in vegetation samples also showed good correlation. This strongly indicates that the distribution of these radionuclides on vegetation reflected their presence in the resuspendable particle size fraction of the aged fallout material at nuclear sites. (Authors) *Keywords:* NAEG*, vegetation*, radiation*

594 **ROMNEY, E.M., R.B. HUNTER, and A. WALLACE. 1989. Field trip report: natural and managed recovery of vegetation on disturbed areas at the Nevada Test Site, pp. 344-349. In: Proceedings of the Symposium on Cheatgrass Invasion, Shrub Die-off, and Other Aspects of Shrub Biology and Management. McArthur, E.D., E.M. Romney, S.D. Smith, and P.T Tueller (Eds.), Las Vegas, NV, April 5-7, 1989. Gen Tech. Rep. INT-276. USDA Forest Service, Ogden, UT.**

An all-day field trip to the Nevada Test Site was conducted on April 6, 1989, as part of the Sixth Wildland Shrub Symposium program. Included were visits to above-ground nuclear event sites, nuclear cratering sites, rangeland fire burn sites, and waste management sites in order to observe natural and managed recovery of vegetation on disturbed Mojave Desert land. This report presents conditions observed in terms of the recovery processes involved rather than by route of travel and observation stops. (Authors) *Keywords:* perturbations*, vegetation*, revegetation*

595 **ROMNEY, E.M., H.M. MORK, and K.H. LARSON. 1970. Persistence of plutonium in soil, plants and small mammals. Health Physics 19: 487-491.**

Periodic surveys during a 10-yr period were made of the persistence of residual Pu-239 in soil, plants and small mammals indigenous to fallout areas contaminated with Pu-239 dispersed by high explosive detonations. Downward migration of fallout particles occurred in undisturbed soil profiles, and wind and water erosion accounted for some redistribution of the initial Pu-239 contamination. Long-term cropping experiments showed a relatively low degree of Pu-239 transfer from soil to plants, but there was a consistent increase in its accumulation in plant tissue during a 5 yr cropping sequence. Plant uptake of Pu-239 from soil was enhanced by DTPA chelating agent. Qualitative trends from these surveys indicate that the accumulation of residual Pu-239 in kangaroo rats and jackrabbits was highest in bone tissue; considerable amounts also were found in lung tissue. Inhalation is known to be the major pathway for plutonium deposition in lung and bone, but the high levels found in the gastrointestinal tracts indicate that ingestion is also an important route through which these small mammals maintained contact with the residual Pu239 contamination in the environment. (Authors) *Keywords:* radionuclide inventory*, vegetation*, mammal*, nutrition/diet*, radiation*

596 **ROMNEY, E.M., H. NISHITA, and A. WALLACE. 1960. Transfer of radioactive fallout debris. Calif. Agriculture 14(3):6, 14, 15.**

Describes the uptake of Sr-90 and Cs-137 by agricultural crops growing on different soils, and methods for reducing accumulation. (TPO) *Keywords:* vegetation*, nutrition/diet*, radiation*

597 **ROMNEY, E.M., A. WALLACE, and J.D. CHILDRESS. 1973. Revegetation problems following nuclear testing activities at the Nevada Test Site. In: (Nelson, D.J., Ed.) *Radionuclides in Ecosystems*, Proceedings of the Third National Symposium on Radioecology (CONF-710501), pp. 1015-1022.**

Areas of disturbed native vegetation on the Nevada Test Site are rapidly invaded by both indigenous and introduced species of winter annual plants. Decades are required for revegetation of perennial shrubs to their former state. On Pahute Mesa adequate germination and survival of native shrubs have returned disturbed areas to nearly original Great Basin Desert conditions. During severe drought browsing animals reduced seedling densities. In Mohave Desert portions of NTS germination and survival of native shrubs is much slower. If seedlings are protected from browsing animals, transplanting can be a practical method for accelerating revegetation of disturbed areas. (TPO) *Keywords:* perturbations*, invasive species*, vegetation*, annual plants*, vertebrate*, revegetation*

598 **ROMNEY, E.M., A. WALLACE, and R.B. HUNTER. 1978. Plant Response to Nitrogen Fertilization in the Northern Mojave Desert and its Relationship to Water Manipulation. In: Nitrogen in Desert Ecosystems. US/IBP Synthesis Series 9, Dowden Hutchinson, and Ross. Stroudsburg, PA, pp. 232-243.**

Studies made of interactions between the most common factors limiting productivity of desert ecosystems (levels of soil moisture and available nitrogen) resulted in several salient conclusions: 1. Considerable water can be applied to Mohave Desert ecosystems with little if any, response in primary productivity if the timing of application is such that the moisture recharge level in soil is already high. If rainfall has been sparse and the recharge soil moisture level is low prior to the onset of the spring growth season, the response can be dramatic when irrigation is superimposed. 2. Water can be limiting for some plant species (especially annuals) and at the same time not be limiting to other plants (especially perennials) growing side by side when moisture near the soil surface is depleted. 3. The most common effect of supplemental moisture is that of extending the growth season of plants. Spring and summer irrigation, however, will not overcome high temperature dormancy of many Mohave Desert plants. 4. The nitrogen cycle in the northern Mohave Desert operates in a manner which will supply adequate nitrogen even in high rainfall years, but nitrogen stress can develop with supplemental irrigation Which increases plant density and/or changes species composition. 5. The natural fertility of the northern Mohave Desert is concentrated in "fertile glands" produced underneath shrub clumps. Nitrogen stress occurs outside these islands when high rainfall years or supplemental moisture result in plants ;rowing in the open area. 6. Many native desert species will not, respond eventually will be replaced by other specie additional soil moisture more effectively. 7. Air and soil temperatures are important moisture and nitrogen. 8. Broadcast applications of nitrogen fertilizer water from rainfall or irrigation has moved zones. Under conditions of soil moisture stress, addition of moisture generally will mask growth responses from supplemental nitrogen. (Authors) *Keywords:* IBP*, hydrology*, soil property*, vegetation*, perennial plants*, physiology*, nutrition/diet*

599 **ROMNEY, E.M., A. WALLACE, and R.B. HUNTER. 1980. The Pulse Hypothesis in the Establishment of *Artemisia* seedlings at Pahute Mesa, Nevada. Great Basin Naturalist Memoirs 4:28-30.**

New *Artemisia* seedlings are not established each year. Many that are established fail to survive because of unfavorable rainfall in succeeding years. If old plants are killed, seeds germinate with much lower inputs of precipitation. Many seedlings germinated at a site where old ones had been burned off, even though the rainfall was not favorable. Seedlings germinating in wild stands grew little in comparison with those germinating in areas where old plants had been killed. One exception was an area where intense competition occurred due to large numbers of new plants, resulting in growth restriction on all plants. (Authors) *Keywords:* climate*, perennial plants*, life history*

600 **ROMNEY, E.M., A. WALLACE, and R.B. HUNTER. 1989. Pulse establishment of woody shrubs on denuded Mojave Desert land, pp. 54-55. In: Wallace, A., E.D. McArthur, and M.R. Haferkamp (Compilers), Proceedings of the Symposium on Shrub Ecophysiology and Biotechnology; 1987 June 30 - July 2; Logan, UT. General Technical Report INT-256, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.**

Denuded Mojave desert land usually requires decades of time for restoration of woody shrubs through natural revegetation processes. We had opportunity to observe pulse establishment of *Ambrosia dumosa* and *Larrea tridentata* onto land that had been disturbed by grading followed by rare events of above-normal rainfall in southern Nevada. Grazing jackrabbits severely damaged unprotected new shrubs. Findings on survival and development of cohort seedling populations indicate that this pulse-triggered establishment of new shrubs resulted from two successive years of above-normal summer rainfall, plus normal winter precipitation, following the year of germination. (Authors) *Keywords:* climate*, perturbations*, perennial plants*, life history*

601 **ROMNEY, E.M., A. WALLACE, and R.B. HUNTER. 1989. Transplanting of native shrubs on disturbed land in the Mojave Desert, pp. 50-53. In: Wallace, A., E.D. McArthur, and M.R. Haferkamp (Compilers), Proceedings of the Symposium on**

Shrub Ecophysiology and Biotechnology; 1987 June 30 - July 2; Logan, UT. General Technical Report INT-256, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Restoration of native shrubs on disturbed land is a very slow natural process in the Mojave desert; however, the time required can be shortened markedly with managed transplanting and husbandry procedures. Tests conducted on denuded desert land in southern Nevada have shown that native shrubs can be transplanted at reasonable cost to obtain significant cover and density within a 5 to 7-year period by using selected species, by protecting them from grazing jackrabbits, and by supplying nutrient supplements. (Authors) *Keywords:* perturbations*, perennial plants*, revegetation*

602 **ROMNEY, E.M., A. WALLACE, and J.E. KINNEAR. 1978. Plant Uptake of Pu and Am Through Roots in Nevada Test Site Soil. In: *Selected Environmental Plutonium Research Reports of the NAEG.* White, M.G., and P.B. Dunaway (Eds.). NVO-192 Volume 1, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 109-120.**

Plant uptake experiments were conducted under controlled conditions in order to eliminate external contamination of plant foliage by resuspended materials. This was done to determine plant uptake of $^{239,240}Pu$ and ^{241}Am through roots and translocation to aboveground parts of plants grown on soils from "safety-shot" fallout areas at the Nevada Test Site (NTS) and Tonopah Test Range (TTR). Experimental details and initial results were reported earlier (Romney *et al*., 1977). Additional interpretations of findings from these experiments indicate the following: 1. Vegetation to soil concentration ratios (C.R.), which serve as an index of root uptake, varied from 10^{-5} to 10^{-3} for $^{239-240}Pu$ and from 10^{-4} to 10^{-1} for ^{241}Am, depending upon the kind of soil involved and the agricultural amendments applied. 2. On the relative basis, Am was taken up at a faster rate than Pu as indicated by mean Am C.R./mean Pu C.R. values (4.2 for barley, 9.9 for alfalfa, and 21.6 for soybeans). 3. DTPA chelate increased root uptake of both Pu and Am when added in conjunction with nitrogen, organic matter, or sulfur amendments. This enhancement effect of chelate on root uptake was more pronounced in soils from Areas 11 and 13 of the Nevada Test Site than it was in soils from different locations on the Tonopah Test Range. Differences in soil characteristics might be influential, but the residence time of the fallout debris in the soils also might have influenced availability from the high-fired oxide source materials deposited in 1956-57 at NTS and in 1963 at TTR. 4. C.R. values were lower for fruit than for vegetative parts of soybeans. 5. Am was slightly more mobile for transport from shoots to fruits of soybeans than was Pu. 6. The correlation coefficients between Pu and Am in shoots and fruiting

parts of soybeans were +0.988 for Pu and +0.983 for Am. (Authors) *Keywords:* NAEG*, perennial plants*, annual plants*, nutrition/diet*, radiation*

603 **ROMNEY, E.M., G.V. ALEXANDER, G.M. LE ROY, and K.H. LARSON. 1959. Influence of stable Sr on plant uptake of Sr 90 from soils. Soil Science 87:42-45.**

Varied treatments of $Sr(N0_3)_2$ and $SrS0_4$ were applied to three different types of Sr-90-contaminated soil to determine to what extent stable Sr might reduce plant uptake of radiostrontium by the effect of carrier dilution. Applications of stable Sr at levels ranging from 0.1 to 5.0 me. Sr per 100 g. of air-dry soil increased the uptake of Sr-90 by beans and Ladino clover. Stable Sr displaced Sr-90 adsorbed on the soil exchange complex into the soil solution where it was more readily available to the plant. This effect was most apparent in an acidic soil containing a very low level of native Sr. Stable Sr uptake was linear with respect to the level of exchangeable Sr in the soil; however, the total amount of Sr accumulated by the plant was dependent upon the available soil calcium. Plants obtained more stable Sr from Sr $(N0_3)_2$-treated soils than from $SrS0_4$-treated soils. The levels of stable Sr required to effectively reduce plant uptake of Sr-90 from soils by carrier dilution were greater than 5.0 me. Sr per 100 g. of soil, that is, equivalent to more than about 5 tons of Sr amendments an acre. (Authors) *Keywords:* annual plants*, nutrition/diet*, radiation*

604 **ROMNEY, E.M., G.V. ALEXANDER, H. NISHITA, and K.H. LARSON. 1961. Influence of Ca and Sr amendments on Sr^{90} uptake by Ladino clover upon prolonged cropping. Soil Sci. Soc. Amer. Proceedings 25:299-301.**

Prolonged cropping experiments showed that a single application of $CaC0_3$ in the amount recommended to produce better crop growth (2 to 5 tons an acre) continued to suppress Sr-90 uptake from an acidic soil that initially was deficient in plant-available Ca. This effect of treatment is attributable to the complementary ion influence of Ca on Sr. The cumulative amount of Sr90 removed by 15 successive cuttings of Ladino clover was 29.38, 15.71, and 11.61% of the dose from Sassafras sandy loam treated with $CaC0_3$ at levels of 1, 5, and 10 me Ca per 100 g soil (equivalent to 0.5, 2.5 and 10 tons $CaC0_3$ an acre, respectively). The greatest amount of the Sr-90 dose removed from the soil by a single clover cutting was 0.38% at the 1 me Ca treatment. A single application of $Sr(N0_3)_2$ amendment at levels of 0.05, 1, and 2 me Sr per 100 g soil (equivalent to 0.05, 1 and 2 tons $Sr(N0_3)_2$ an acre) initially increased plant uptake of Sr-90 from Hanford sandy loam as a result of the displacement of Sr-90 from the exchange complex by stable Sr into the soil solution where it was more readily available to the plant. This enhancing effect of low levels of Sr amendment of Sr-90 uptake became less apparent as time progressed. The carrier-dilution effect of reducing plant uptake of Sr-90 from Hanford sandy loam was achieved by applying $Sr(N0_3)_2$ at a level of 10 me Sr per 100 g soil (equivalent to 10 tons $Sr(N0_3)_2$ an acre). (Authors) *Keywords:* annual plants*, nutrition/diet*, radiation*

605 **ROMNEY, E.M., G.V. ALEXANDER, W.A. RHOADS, and K.H. LARSON. 1959. Influence of calcium on plant uptake of Sr 90 and stable strontium. Soil Science 87:160-165.**

The effects of applied Ca on uptake of Sr-90 by beans from nutrient solutions independent of soil factors was studied. In general Ca inhibited Sr uptake when applied in amounts equivalent to 2 to 5 t/acre. (TRH) *Keywords:* annual plants*, nutrition/diet*, radiation*

606 **ROMNEY, E.M., W.L. EHRLER, A.H. LANGE, and K.H. LARSON. 1960. Some environmental factors influencing radiostrontium uptake by plants. Plant and Soil 12:41-48.**

Uptake of Sr-90 from Vina soil was measured in several agricultural crop plants, and varied by a factor of 10 within the species tested. In cereals the amount of Sr-90 was 20% less than that in the forage. Tubers of potatoes contained only 2% of what was found in their tops, and uptake was inversely correlated with the level of plant-available calcium in three soils. Lowering root temperatures from 17° to 7° significantly reduced uptake by barley and beans. Decreased light intensity or duration of light exposure reduced uptake by barley and beans. (TPO) *Keywords:* annual plants*, perennial plants*, nutrition/diet*, radiation*

607 **ROMNEY, E.M., H. NISHITA, J.H. OLAFSON, and K.H. LARSON. 1963. Root transfer of fission products from contaminated soil. Soil Sci. Soc. Amer. Proceedings 27:383-385.**

Dry yield of wheat grown for 117 days was not affected by solutions of nuclear reactor-produced mixed fission products (MFP) applied to the soil surface or mixed with equal amounts of potted soil at contamination level ranging from 0.1 to 1.0 uC beta activity per g of soil. Concentrations of beta and gamma activity in the above-ground parts of plants were increased as the soil contamination levels increased. Wheat removed from 0.07 to 0.09% of the total beta activity that had been mixed with the soil and from 0.10 to 0.15% of that which had been applied to the soil surface. Concentrations of radioactivity in above-ground plant parts were highest in leaves, intermediate in stems and lowest in fruiting heads. Radiostrontium accounted for 50 to 80% of the beta activity transferred to above-ground plant parts; <10% was attributable to root transfer of Y-91, Ru-106, Cs-137, and Ce-144 from soil. (Authors) *Keywords:* annual plants*, nutrition/diet*, radiation*

608 **ROMNEY, E.M., W.A. RHOADS, A. WALLACE, and R.A. WOOD. 1973. Persistence of radionuclides in soil, plants, and small mammals in areas contaminated with radioactive fallout. In: Third-National (Nelson, D.J., Ed.) *Radionuclides in Ecosystems*, Proceedings of the Third National Symposium on Radioecology (CONF-710501), pp. 170-176.**

The persistence of radionuclides in soil, plants, and small mammals was investigated periodically in areas contaminated with fallout from aboveground nuclear detonations at the Nevada Test Site. Study sites were established at various locations out to about 225 km from ground zero. Emphasis was placed upon the movement of Sr-90 and Cs-137 from abiotic to biotic components. Several neutron activation products also were studied in fallout areas located within 5 km of nuclear excavation tests. Radionuclides continued to be taken up through plant roots in small amounts, as time progressed, and some continued to be deposited on foliage as resuspended dust particles. The inhalation route of entry became less important with passing time, whereas ingestion continued to be the most important route through which radionuclides entered small mammals living in old fallout areas. Long-lived Sr-90 accumulated primarily in bone tissue, while Cs-137 accumulated in muscle and soft tissue. Most of the neutron activation products are shortlived but among those found in animal tissues were isotopes of Co, Mn, and W. Findings indicate that Sr-90 and Cs-137 will continue to move in small amounts from abiotic to biotic components in fallout-contaminated areas with passing time. (Authors) *Keywords:* radionuclide inventory*, vegetation*, mammal*, nutrition/diet*, radiation*

609 **ROMNEY, E.M., A.J. STEEN, R.A. WOOD, and W.A. RHOADS. 1967. Concentration of radionuclides by plants grown on ejecta from the Sedan thermonuclear cratering detonation. In: (Aberg, B., and F.P. Hungate, Eds.) *Radioecological***

***Concentration Processes*, Proceedings of the International Symposium, Stockholm, April 1966 (CONF-660405), pp. 391-398.**

Native and domestic plants grown on ejecta from the Sedan thermonuclear cratering detonation concentrated high levels of radiotungsten, and smaller amounts of Sc-46, Mn-54, Co-60, Y-88, Sr-89, Sr-90, Zr-95, Ru-106, Sb-125, Cs-134, Cs-137, and Ce-144 through their roots. Uptake of these radionuclides persisted through the 3-year cropping period post- detonation. Plant foliage contaminated by Sedan fallout contained Rb-86, Y-91, Ru-102, Ru-103, I-131, Cs-156, Ba-140, Ce-141, Eu-152 and Eu-154; but these radionuclides were not concentrated through roots in later cropping experiments. Radioactive dust continued to be deposited on the foliage of plants re-established on Sedan ejecta. (Authors) (TPO) *Keywords:* vegetation*, nutrition/diet*, radiation

610 **ROMNEY, E.M., A. WALLACE, R.O. GILBERT, and J.E. KINNEAR. 1975. $^{239\text{-}240}$Pu and ^{241}Am Contamination of Vegetation In Aged Plutonium Fallout Areas. In: *The Radioecology of Plutonium and Other Transuranics in Desert Environments.* White, M.G., and P.B. Dunaway (Eds.). NVO-153, U.S. Energy Research & Development Administration, Nevada Operations Office, Las Vegas, NV, pp. 43-87.**

This interim report contains data on the $^{239\text{-}240}$Pu and ^{241}Am contents of vegetation samples collected in conjunction with the Nevada Applied Ecology Group (NAEG) soil sampling program in aged plutonium fallout areas on the Nevada Test Site (NTS) and the Tonopah Test Range (TTR). Radiochemical analyses essentially have been completed on samples collected from the GMX site in Area 5 and the Project 57 site in Area 13. About 60 percent of the vegetation samples collected from the Area 11 sites at NTS and Roller Coaster sites at TTR have undergone radiochemical analysis. Preliminary data indicate definite variations in contamination levels from sample to sample collected within a given activity stratum defined by the FIDLER survey instrument. Variations also occur in contamination levels on different plant species which can be attributed to differences in amounts of resuspendable particulate material superficially entrapped upon plant foliage. In spite of these variations, there are some indications of reasonable agreement between the mean activity levels of $^{239\text{-}240}$Pu in vegetation and soil samples collected across the different activity strata within each fallout area. In addition, there are indications that the ratio of vegetation Pu to soil Pu increases as one proceeds from higher to lower activity strata. A limited particle size range of resuspendable material superficially deposited upon vegetation could account for some of the variations in activity levels and ratios noted when comparing vegetation and soil data. Sufficient data have been acquired to indicate a reasonably constant Pu/Am ratio for vegetation samples collected from a given fallout area. This ratio, however, varies among separate events as the result of differences in the ingrowth of ^{241}Am within aged fallout source materials. The Pu/Am ratios tend to be lower in vegetation than in soil samples for each event studied, except for the Area 5-GMX site where multiple tests were conducted. The lower ratios in vegetation samples are presumed to result from a referential uptake by plant roots of the more biologically available ^{241} Am as compared to $^{239\text{-}240}$Pu in these aged fallout areas. The $^{239\text{-}240}$Pu inventory estimates for Area 13 indicate that standing

vegetation contributes a rather insignificant portion of the total contaminant present in aged fallout areas. (Authors) *Keywords:* NAEG*, radionuclide inventory*, vegetation*, nutrition/diet*, radiation*

611 **ROMNEY, E.M., A. WALLACE, R.O. GILBERT, and J.E. KINNEAR. 1976. ^{239,240}Pu and ^{241}Am Contamination of Vegetation In Aged Fallout Areas. In: *Transuranium Nuclides in the Environment.* International Atomic Energy Agency, Vienna, Austria, pp. 479-491. DOE/NV Accession #NV0064800.**

Vegetation studies in aged plutonium fallout areas showed variations in the $^{239\text{-}240}$Pu and ^{241}Am contamination levels attributable to differences in the amounts of resuspendable particulate material superficially entrapped upon plant foliage. There was reasonable agreement between the mean activity levels in vegetation and soil samples collected across different activity strata defined by FIDLER survey instrument within each fallout area. The ratio of vegetation Pu to soil Pu tended to increase moving out from higher to lower activity strata, which might reflect the increasing proportion of finer particulate material initially deposited in fallout debris at greater distance from ground zero. The Pu/Am ratio was reasonably constant for vegetation samples collected from a given fallout area. This ratio, however, varied among separate test events primarily as the result of differences in the ingrowth of ^{241}Am within the aged source materials. Inventory estimates indicate that standing vegetation contributes a rather insignificant portion of the total contaminant remaining in these aged fallout areas. (Authors) *Keywords:* radionuclide inventory*, vegetation*, radiation*

612 **ROMNEY, E.M., A. WALLACE, H. KAAZ, and V.Q. HALE. 1980. The Role of Shrubs on Redistribution of Mineral**

Nutrients in Soil in the Mojave Desert. Great Basin Naturalist Memoirs 4:124-133.

Soil profiles underneath shrub clumps and bare desert pavement were examined at 62 study sites located in both open and closed drainage basins of the northern Mojave Desert. Highly significant differences occurred in the root zone underneath shrub clumps with higher concentrations of the following soil properties: electrical conductivity, Na, K^+, Ca^{++}, Mg^{++}, Cl^-, NO_3^-, and $SO_4^=$ exchangeable K^+; cation exchange capacity; organic C and N; available P, and DTPA-extractable Fe and Mn. These differences reflect differential cycling caused by different plant species. The decomposition and mineralization of litter deposited underneath the perennial vegetation can account for these differences in soil properties which, collectively, increase the fertility of the soil underneath the vegetation canopy. Aboveground biomass of shrubs was measured and the nitrogen and mineral element composition of new photosynthetic tissue was determined. Estimates from a representative study site indicate that the reservoir of nitrogen and mineral nutrients in new leaf material of shrubs available for litter deposition could contribute 3.64 kg N, 0.31 kg P, 0.57 kg Na, 5.20 kg K, 4.95 kg Ca, 31.82 g Fe, and 4.30 g Mn per hectare. This source probably represents about one-third of the total amount of nutrients involved in annual turnover for the study area during a normal production year. The remaining contribution would be supplied from the standing dead wood in shrubs and as litter from annual plant species. (Authors) *Keywords:* soil property*, perennial plants*, ecology/ecosystem*, nutrition/diet*

613 **ROMNEY, E.M., A. WALLACE, J.E. KINNEAR, and R.O. GILBERT. 1977. Estimated Inventory of Plutonium and Uranium Radionuclides for Vegetation in Aged Fallout Areas. In: *Environmental Plutonium on the Nevada Test Site and Environs*. White, M.G., P.B. Dunaway, and W.A. Howard (Eds.). NVO-171, Nevada Applied Ecology Group, U.S. Energy Research & Development Administration, Las Vegas, NV, pp. 35-52.**

This interim report is third in a series reporting data pertinent to the contamination of vegetation by plutonium and other radionuclides in aged fallout areas on the Nevada Test Site (NTS) and the Tonopah Test Range (TTR). The standing biomass of vegetation estimated by nondestructive dimensional methods varied from about 200 to 600 g/m^2 for the different fallout areas. Estimated $^{239,240}Pu$ inventories (in millicuries) for vegetation of sites located at NTS were 0.47 for Area 5 (GMX); 0.098, 2.2, 3.8, and 6.7 for Area 11, Sites A, B, C, and D, respectively; and 28.2 for Area 13 (Project 57). The inventory estimates for sites at TTR were 0.39, 0.54, 2.6, and 5.7 for DT, CS1, CS2, and CS3, respectively. Estimated standard errors for these inventory estimates are given in this report. Comparisons of soil and vegetation inventory estimates indicate that the standing vegetation contributes an insignificant portion of the total amount of $^{239,240}Pu$ present in these aged fallout areas. The amounts of plutonium available for vegetation-transport to animals grazing on-site would appear to be relatively small in comparison to the total amounts deposited upon soil. Findings indicate that most of the contaminant found on vegetation probably is attributable to resuspendable materials. For dose sites presently under investigation, the contamination level on vegetation amounts, in almost all cases, to less than one-thousandth of that which is present on soil. It is important to recognize that the standing vegetation of these aged fallout areas acts as a windbreak and probably reduces the amount of contaminant that otherwise would move by resuspension should these fallout areas ever become denuded. Inventory estimates of total uranium for vegetation varied among the different fallout areas from about three grams for Site A in Area 11 to more than 200 grams for the large (4.7×10^6 m^2) ABCD region in Area 11. Too few samples have been analyzed to ascertain the significance of the uranium results and their relationship to original fallout depositions and natural background levels at this point in time. (Authors) *Keywords:* NAEG*, radionuclide inventory*, vegetation*, ecology/ecosystem*, radiation*

614 **ROMNEY, E.M., R.G. LINDBERG, H.A. HAWTHORNE, B.G. BYSTROM, and K.H. LARSON. 1963. Contamination of plant foliage with radioactive fallout. Ecology 44:343-350.**

Fallout particles less than 44 µ diameter were selectively trapped in the hairs and crevices and on resinous glands of the leaf surfaces of foliage contaminated with fallout from nuclear detonations. Beta activity on plant foliage was correlated with the beta activity from fallout particles less than 44 u diameter. Decontamination treatments using washing with mild detergents and chelating agents reduced levels of radioactivity by half. Fallout on plant foliage that originated from tower-supported detonations was 5 to 35 percent soluble in 0.1 N HCL; fallout from balloon-supported detonations was 60 to 90 percent soluble. Radioisotopes of cerium, yttrium and zirconium contributed about 60 percent of the beta activity found in smaller than 44 micron diameter fallout particles (90 days after detonation); radiostrontium accounted for nearly 5 percent and radiocesium contributed less than 1 percent. (Authors) (TPO) *Keywords:* radionuclide inventory*, vegetation*, radiation*

615 **ROMNEY, E.M., J.W. NEEL, H. NISHITA, J.H. OLAFSON, and K.H. LARSON. 1957. Plant uptake of Sr90, Y91, Rul06,**

Cs137, and Ce144 from soils. Soil Science 83:369-376.

Soil pot experiments conducted in 1952 and 1953 showed virtually no Y-91, Ru-106, Cs-137, or Ce-144 were taken up from different soils by barley, bean, carrot, lettuce, and radish plants. Sr-90 was readily taken up and was concentrated in greatest amounts in leaf tissue. Radish tops accumulated the greatest amounts of Sr-90 per unit weight, followed by beans, carrots, lettuce, and barley, in decreasing order. Soil types influenced Sr790 uptake. Highest Sr-90 levels were found in plants grown on acidic soils low in Ca and lowest levels on alkaline calcareous soils. Intensive cropping is apparently not effective for the removal of fission products from soils within a short cropping period. (Authors) *Keywords:* annual plants*, nutrition/diet*, radiation*

616 **ROMNEY, E.M., A. WALLACE, H. KAAZ, V.Q. HALE, and J.D. CHILDRESS. 1977. Effect of Shrubs on Redistribution of Mineral Nutrients in Zones Near Roots in the Mojave Desert. In: The Belowground Ecosystem: A Synthesis of Plant-Associated Processes. Marshall, J.K. (Ed.), Range Science Department Science Series No. 26, Colorado State University, Fort Collins, CO, pp. 303-310.**

The influence of shrubs on cycling or redistribution of nitrogen and mineral nutrients in zones near roots was investigated in some northern Mojave Desert areas of the Nevada Test Site where the perennial vegetation exists as solitary shrubs and as shrub clumps consisting of several different species. The soils have developed on alluvium sediments, and many of them are underlaid with restrictive hardpan at depths varying from 30 to 70 cm. Soil profiles underneath shrub clumps and bare desert pavement were examined at 62 study sites located in both open and closed drainage basins. Highly significant differences occurred in the root zone underneath shrub clumps with higher concentrations of the following soil properties: electrical conductivity, soluble Na^+, K^+, Ca^{++}, M^{++}, Cl^-, $N0_3^-$, and SO_4^-; exchangeable K^+; cation exchange capacity; organic C and N; available P; and DTPA-extractable Fe and Mn. The decomposition and mineralization of litter deposited underneath the perennial vegetation can account for these differences in soil properties which, collectively, increase the fertility of the soil underneath the vegetation canopy. Aboveground biomass of shrubs was measured and the nitrogen and mineral element composition of new photosynthetic production was determined. Estimates from a representative study site indicate that the reservoir of nitrogen and mineral nutrients in new leaf material of shrubs available for litter deposition could contribute 3.64 kg N, 0.31 kg P, 0.57 kg Na, 5.20 kg K, 4.95 kg Ca, 31.82 g Fe, and 4.30 g Mn per hectare. This source probably represents about one-third of the total amount of nutrients involved in annual litter-fall for the study area during a normal production year. The remaining contribution would be supplied from the standing dead wood in shrubs and as litter from annual plant species. (Authors) *Keywords:* soil property*, perennial plants*, ecology/ecosystem*, nutrition/diet*

617 **ROMNEY, E.M., A. WALLACE, R.O. GILBERT, S.A. BAMBERG, J.D. CHILDRESS, J.E. KINNEAR, and T.L. ACKERMAN. 1973. Some ecological attributes and plutonium contents of perennial vegetation in Area 13. USAEC Report UCLA 12-937, 17 pp.**

Preliminary data are presented on levels of Pu-239, 240 and Am-241 in samples of vegetation collected in the Project 57 fallout pattern, Area 13. Some data on floral ecology of the site are also included. Estimates of ground cover ranged from 12.8 to 28.3 percent. Shrub densities ranged between 11.2 x 103 and 17.9 x 103 plants per hectare, and standing shrub biomass ranged from 1592 to 4285 kilograms per hectare (0.7 to 1.9 tons per acre). Within intensive study plots there was a uniform distribution of Pu-239,240 and Am-241 among individual samples of the same plant species. However, there was considerable variation in contamination levels between different species. Concentrations in *Eurotia Lanata* were three to five times higher than in other species sampled. Levels of Pu239, 240 and Am-241 in vegetation samples generally decreased with increasing distances from ground zero, but there were poor correlations between vegetation and soil concentrations in isopleth strata within a grazed site. Lower Pu/Am ratios in vegetation indicate that preferential uptake of Am-241 may have occurred. (TPO) *Keywords:* radionuclide inventory*, vegetation*, perennial plants*, nutrition/diet*, ecology/ecosystem*, radiation*

618 **ROMNEY, E.M., A. WALLACE, R.O. GILBERT, S.A. BAMBERG, J.D. CHILDRESS, J.E. KINNEAR, and T.L. ACKERMAN. 1974. Some Ecological Attributes and Plutonium Contents of Perennial Vegetation in Area 13. In: *The Dynamics of Plutonium in Desert Environments*. Dunaway, P.B., and M.G. White (Eds.). NVO-142, U.S. Atomic Energy Commission, Nevada Operations Office, Las Vegas, NV, pp. 91-106.**

This interim report includes data on the ecological attributes of vegetation in Area 13, Nevada Test Site (NTS), as well as data on the $^{239\text{-}240}$Pu and ^{241}Am in samples of vegetation collected in conjunction with the soil sampling program in Area 13. Prominent shrub and grass species in the fallout pattern of Area 13 include *Artemisia spinescens, Atriplex canescens,* *Atriplex confertifolia, Eurotia lanata, Grayia spinosa, Kochia americana, Lycium andersonii*, and *Oryzopsis hymenoides*. Individual or codominant species distinguished local association patterns of varied size within the fenced study area. Vegetation cover estimates in sample study plots ranged from 12.8 to 28.3%. Shrub densities ranged from 11.2 x 10^3 to 17.9 x 10^3 plants per hectare, and the standing shrub biomass ranged from 1,592 to 4,285 kg per hectare (0.7 to 1.9 tons per acre). Preliminary results showed rather uniform distributions of $^{239-240}$Pu and ^{241}Am among individual samples of the same plant species collected within an intensive study plot. However, there was considerable variation in the contamination levels between different species, presumably from superficial entrapment of resuspended particulate material. Concentrations in *Eurotia lanata* were three to five times higher than in other species sampled from the same study site. The $^{239-240}$Pu and ^{241}Am generally tended to decrease in samples of vegetation collected at increasing distances from ground zero, but there were poor correlations between vegetation and soil $^{239-240}$Pu concentrations in isopleth strata within the fenced grazing area. Results showed inconsistencies in the Pu/Am ratios for vegetation and soil. Lower ratios found in vegetation samples indicate that preferential uptake and concentration of ^{241}Am through plant roots might have occurred in the Project 57 area. (Authors) *Keywords:* NAEG*, radionuclide inventory*, perennial plants*, annual plants*, nutrition/diet*, ecology/ecosystem*, radiation*

619 ROMNEY, E.M., A. WALLACE, J.D. CHILDRESS, J.E. KINNEAR, J. KAAZ, P.A.T. WIELAND, M. LEE, and T.L. ACKERMAN. 1974. Responses and interactions in desert plants as influenced by irrigation and nitrogen applications. US/IBP Desert Biome Res. Memo. 74-17. Utah State University, Logan, 12 pp.

Some examples are reported of responses and interactions of Mohave Desert vegetation to soil surface applications of supplemental nitrogen and sprinkler irrigation. Results of preliminary studies agree with findings reported for grasslands in that surface applications of nitrogen generally were ineffective for increasing primary productivity when soil moisture was limiting. When followed by natural precipitation or sprinkler irrigation, broadcast fertilization of nitrogen was most beneficial to the annual plant species, increasing both herbage yield and nitrogen content of plant tissue. Shrubs responded in like manner when the nitrogen and moisture had penetrated into the root zone; those having the highest natural grazing potential, viz. *Ambrosia dumosa, Ceratoides lanata* and *Lycium andersonii*, consistently showed the most favorable response. There was marked establishment of new seedlings of *Acamptopappus shockleyi, Ambrosia dumosa, Ceratoides lanata*, and *Sphaeralcea ambigua* from sustained moisture treatments. Also, there appeared to be a growth-response plateau for most species above which further additions of either supplement would be ineffective. Two species, *Ephedra funerea* and *Larrea divaricata*, showed some evidence of new shoot damage from prolonged sprinkler irrigation. Growth of annual species on bare soil between shrub clumps also was inhibited in sprinkler-irrigated plots, presumably from mechanical impact damage and sun scald. Inasmuch as soil moisture is the most limiting factor affecting primary productivity in the Mohave Desert, its enhancement generally masked any growth response that might have been attributable to supplemental nitrogen. Additions of supplemental moisture markedly increased the productivity of native grasses indicating that sustained treatment should increase the grassland grazing potential of Mohave Desert areas. (Authors) *Keywords:* IBP*, hydrology*, soil property*, perennial plants*, annual plants*, ecology/ecosystem*, nutrition/diet*

620 ROMNEY, E.M., V.Q. HALE, A. WALLACE, O.R. LUNT, J.D. CHILDRESS, H. KAAZ, G.V. ALEXANDER, J.E. KINNEAR, and T.L. ACKERMAN. 1973. Some characteristics of soil and perennial vegetation in northern Mojave Desert areas of the Nevada Test Site. USAEC Report UCLA 12-916, 340 pp.

Data were compiled from several interrelated projects conducted at the Nevada Test Site as part of a team effort to obtain more information on soil and plant relationships in the desert ecosystem in order to better understand the impact of nuclear testing on the environment. It ties together the masses of acquired data into one convenient volume for use by the funding agency and also to serve as a basis for the continuing systems analysis work involved with these projects. Included are results from the chemical and physical characterization of soil profiles at 79 study sites located in some northern Mojave Desert areas of the Nevada Test Site. These profiles were characterized under clumps of perennial vegetation and under bare desert pavement in order to determine the modifying influence of shrubs on desert soil. Ecological attributes of perennial vegetation determined by nondestructive, dimensional analysis are reported in terms of density, area, volume, and biomass according to the existence of shrubs as solitary plants or as members of a shrub clump. Mineral element compositions of leaves and stems are reported for the most common plant species at each study site. Also included are the concentrations of Cs-137 and the natural K40 (as total K), uranium and thorium found in the surface fractions of the soil profile. Abiotic data compiled during a 5-year period from 9 sampling stations are reported for rainfall, air temperature, soil temperature and soil moisture. (Authors) *Keywords:* soil property*, climate*, radionuclide inventory*, perennial plants*, ecology/ecosystem*, nutrition/diet*

621 **ROWLAND, R.H., and F.B. TURNER. 1964. Correlation of the local distributions of *Dipodomys microps* and *D. merriami* and of the annual grass *Bromus rubens*. Southwestern Nat. 9:56-61.**

The occurrences of *Dipodomys microps* and *D. merriami* in a small area of the Nevada Test Site were examined. The abundance of *D. microps* varies inversely with the abundance of *Bromus rubens*. Reynold's hypothesis that dense grass interferes with escape from predators is reconsidered in terms of grass density and size of rodent. (Authors) *Keywords:* invasive species*, annual plants*, mammal*, ecology/ecosystem*

622 **RUNDEL, P.W., and P.L. GIBSON. 1996. Ecological Communities and Processes in a Mojave Desert Ecosystem: Rock Valley, Nevada. Cambridge University Press. Cambridge, MA.**

Deserts provide a harsh and inhospitable environment for plants and animals, and the ecosystem is correspondingly fragile and prone to disruption by a variety of external factors. The Mojave Desert is a winter-rainfall desert, experiencing drought in the summer months and occasional rain during the cooler winter months. For many years it has attracted the attention of ecologists and conservation biologists concerned to maintain the unique status of this region. This book provides a broad overview of plant and animal ecology in the Mojave Desert, presented with a focus on data from Rock Valley, Nevada. The data from many research projects is organized into a synthesis describing community structure and dynamics in desert ecosystems. (Authors) *Keywords:* climate*, vegetation*, invertebrate*, vertebrate*, ecology/ecosystem*

623 **RUSH, F.E. 1971. Regional ground-water systems in the Nevada Test Site area, Nye, Lincoln, and Clark Counties, Nevada. Water Resources Reconnaissance Series Report 54, 25 pp.**

The area covered by this report includes 16 hydrographic areas between Tonopah and Las Vegas, NV, and centers about the USAEC's Nevada Test Site. The area has an average annual precipitation of about 5 inches on the valley floors to 20 inches in the mountains. Consolidated rocks are mostly volcanic; however, some extensive areas of carbonate rocks have been mapped. Three types of ground-water reservoirs are identified: Valley-fill, volcanic-rock, and carbonate-rock aquifers. Alluvium beneath valley floors is commonly saturated only at great depth. Water in the valleyfill reservoirs generally leaks downward to volcanic or carbonate rocks. In the eastern part of the study area, volcanic-rock aquifers locally transmit water downward to carbonate-rock aquifers. In the western part, the volcanic-rock aquifers transmit a regional flow of water, as do the carbonate-rock aquifers of the eastern part. Transmissivity of volcanic-rock aquifers of the western part averages about 10,000 gal per day per ft. Transmissivity of the carbonaterock aquifer generally is much higher, resulting in low flow gradients. Three regional interbasin groundwater flow systems have been identified: Ash Meadows, in the eastern two-thirds of the area; Pahute Mesa, in the western third; and Sarcobatus Flat, west of the study area and including Cactus Flat. Ground water in the Ash Meadows system flows generally southward to Ash Meadows to discharge at springs, by evapotranspiration, and possibly by subsurface outflow across a fault barrier to the south end of the Pahute Mesa system in Amargosa Desert. The Pahute Mesa system flows generally southward to discharge largely by evapotranspiration in Amargosa Desert. Ground water is believed to flow southwestward from Cactus Flat to Sarcobatus Flat where it is largely discharged by evapotranspiration. Some of the water in the first two systems may move southwestward as underflow to Death Valley through the carbonate rocks of the Funeral Range. The estimated average annual recharge and discharge for the Ash Meadows system are 33,000 and at least 17,000 acre-feet, respectively; for the Pahute Mesa system these estimates are 11,000 and 9,000 acre-feet, respectively; and for the Sarcobatus Flat system, 3,500 acre-feet. For the Ash Meadows and Pahute Mesa systems, which join in Amargosa Desert, the computed excess of recharge over discharge of some 18.000 acre-feet per year may flow southwestward to Death Valley, assuming that substantial errors in the estimates do not exist. Because virtually all the ground-water discharge is by subsurface outflow at considerable depth, most ground-water development probably will be from ground water in storage. One exception is the western part of Groom Lake Valley where an estimated 2,500 acre-feet per year could be salvaged. Beneath valley floors, an estimated 10 million acrefeet of ground water is in transient storage in the uppermost 100 feet of saturation. (Authors) (LE) *Keywords:* geology*, hydrology*, wetlands*

624 **RUSSELL, C.E., R. JACOBSON, D.L. HALDEMAN, and P.S. AMY. 1994. Heterogeneity of deep subsurface microorganisms and correlations to hydrogeological and geochemical parameters. Geomicrobiology Journal 12:37-51.**

Nineteen samples were obtained from a 21-m^3 section of zeolitized volcanic ash fall tuff, 390 m below the surface of Rainier Mesa, Nevada. Rock mined aseptically from the walls of deep subsurface tunnels provided pristine samples for microbiological and geochemical analyses. Microbiological parameters measured on all samples included direct counts and the abundance, diversity, morphology, and metabolic traits of culturable organisms. Physical and chemical parameters measured included ionic and nutrient chemistries, mineralogy, porosity, moisture content, and permeability. The results indicate that the culturable microbiological community size and composition exhibit random spatial variability within the geologically/geochemically homogeneous rock section. The relative abundance of microorganisms testing positive for nitrate reductase demonstrated a spatial trend along the vertical and front-to-back axes of the rock section by gradient analysis. The porewater concentration of nitrate correlated with numbers of bacteria testing positive for nitrate reductase and indicates that these bacteria may exist as dormant forms in situ. (Authors) *Keywords:* geology*, microbiota*, physiology*, ecology/ecosystem*

625 **SAETHRE, M. 1994. Trends in Small Mammal Populations on the Nevada Test Site: 1989 Through 1991. In: Status of the Flora and Fauna on the Nevada Test Site, 1989-91. Hunter, R.B. (Compiler), DOE/NV/11432-57, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 50-140.**

Five years of monitoring selected small mammal populations on the Nevada Test Site were completed in 1991. Monitoring, which began in 1987, focused on trends in heteromyid rodent populations on five baseline sites and included several sites disturbed by the Department of Energy nuclear testing program and site maintenance (e.g., craters, drill pads, blast areas) and by naturally occurring disturbances (e.g., lightning strike fires and gopher areas). Results from the baseline site in western Yucca Flat indicated that small mammal populations declined coincidentally with a local drought from 1988 to 1990. Two species, *Dipodomys merriami* and *Perognathus longimembris*, rebounded during 1991, a year of good ephemeral plant biomass production. Besides animal abundance on baseline sites, monitoring showed that areas where perennial vegetation had been removed by blasting, fires, grading, or gophers supported fewer species of rodents. More complex habitats in the undisturbed areas tended to have significantly greater species diversity. However, with the spring rainfall in 1991, ephemeral plants fared especially well on sites where competition from perennial plants was low (i.e., blasted, graded, gopher areas). Consequently, these sites had higher summer populations of kangaroo rats after

spring reproduction and survival of juveniles. (Author) *Keywords:* perturbations*, mammal*, ecology/ecosystem*, life history*

626 **SAETHRE, M. 1994. Trends in Small Mammal Populations on the Nevada Test Site, 1992. In: Status of the Flora and Fauna on the Nevada Test Site, 1992. Hunter, R.B. (Compiler), DOE/NV/11432-58, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 84-143.**

The sixth year of monitoring selected small mammal populations on the Nevada Test Site was completed in 1992. Monitoring, which began in 1987, continued to focus on trends in heteromyid rodent populations at two baseline sites and included subsidence craters and drill pads generated by the Department of Energy nuclear testing program. A site disturbed by a brush fire in 1988 was also recensused in 1992. Numbers of animals captured on the baseline site in western Yucca flat indicated that the kangaroo rat population (*Dipodomys merriami* and *D. Microps*) continued to rebound from drought conditions which prevailed from 1989 through 1990. The little pocket mouse (*Perognathus longimembris*) declined to the lowest density ever recorded at this site, after being the most abundant rodent from 1987 through 1991. Densities were the highest ever recorded at a human-caused burn area, mostly due to increases in the kangaroo rat population. Murid rodents (*Peromyscus, Onychomys,* and *Neotoma*) also did particularly well at the sites studied in 1992. *Peromyscus maniculatus* was the most common rodent at the Pahute Mesa baseline site in 1992, replacing *Perognathus parvus*. Of the three crater sites, last studied in 1989, two (U10af and U17au) showed increases in the number of individual animals captured, while one (U3cn) experienced a decline. The decline was apparently due to a pair of ravens which repeatedly used the bottom of the crater as a nesting site and the surrounding area for foraging territory. Most other plots sampled during the drought years (1989 and 1990) showed increases in animal abundance after the drought (1991, 1992 and 1993). (Author) *Keywords:* climate*, perturbations*, mammal*, ecology/ecosystem*, life history*

627 **SAETHRE, M. 1994. Trends in Small Mammal Populations on the Nevada Test Site in 1993. In: Status of the Flora and Fauna on the Nevada Test Site, 1993. Hunter, R.B. (Compiler), DOE/NV/11432-162, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 36-123.**

The seventh year of monitoring small mammal populations on the Nevada Test Site was completed in 1993. The Basic Environmental Compliance and Monitoring Program (BECAMP) continued to focus on trends in heteromyid rodent populations at three baseline sites and included a bladed area and roadside disturbance generated by Department of Energy programs. Three sites disturbed by brush fires in 1985, 1986, and 1988 were also recensused in 1993. The second consecutive year of above average rainfall occurred in 1993, after nearly three years of drought. Numbers of animals captured during the spring of 1993 on the baseline site in western Yucca Flat indicated kangaroo rat populations (*Dipodomys merriami* and *D. microps*) continued to rebound from drought conditions which prevailed in 1989 through 1990. *Dipodomys microps*, previously found as or less abundant than *D. merriami*, was the most abundant rodent in 1993. In 1992, the little pocket mouse (*Perognathus longimembris*) declined to the lowest density ever recorded, after being the most abundant rodent from 1987 through 1990. This plot has been trapped yearly since 1987 and has the most complete trapping record of any BECAMP site. Spring density of small mammals on this plot was positively correlated with winter rainfall. Rodents on the baseline plot in western Jackass Flats also recovered since the last census in 1990. This area is more sandy than Yucca Flat and consists of Mojave Desert vegetation. The most common species in 1993 was *Dipodomys merriami*. *Perognathus longimembris* numbers on this plot, as on the Yucca Flat plot, were below pre-drought values. The baseline site on Rainier Mesa was first trapped in 1988 (pre-drought) and censussed again in 1993 (post-drought). Nearly 10 times as many deer mice (*Peromyscus maniculatus*) were captured on this site in 1993 as in 1988, and three times as many chipmunks (*Tamias dorsalis*). Murid rodents (*Peromyscus, Onychomys*, and *Neotoma*) were well represented at sites studied in 1993. *Neotoma lepida*, the desert woodrat, was captured at nearly every site trapped. An undisturbed area in Mid Valley had the highest species diversity for plots studied in 1993 at 0.9309 with eleven species captured. (Authors) *Keywords:* climate*, perturbations*, mammal*, ecology/ecosystem*, life history*

628 **SAETHRE, M. 1995. Small Mammal Populations on the Nevada Test Site, 1994. In: Status of the Flora and Fauna on the Nevada Test Site, 1994. Hunter, R.B. (Compiler), DOE/NV/11432-195, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 76-148.**

In 1994, the Basic Environmental Compliance and Monitoring Program (BECAMP) completed its eighth year of monitoring the small mammal population on the NTS. The project was focused on trends in heteromyid rodent populations at two baseline sites and five areas disturbed by past DOE programs. Other locations sampled were an area denuded by gophers, a fenced and previously irradiated area, and a waste storage site that had been cleaned and revegetated. Additional trapping took place to survey hantavirus around townsites and in areas with expected high deer mouse densities. Kangaroo rats continued to be the most common heteromyid rodent on the NTS. The chisel-toothed kangaroo rat was the most abundant rodent on the Yucca Flat baseline site for the second year in a row. The little pocket mouse persisted at low numbers at most sites in 1994. On the Frenchman Flat baseline site, the number of individuals of this species captured in 1994 was similar to 1988, after nearly disappearing during a drought period. Total numbers inhabiting nuclear event sites were equal to or lower than those at nearby undisturbed sites, however, species diversity was always lower in the blast areas. Species diversity at the Sedan site also increased as distance from the crater edge increased. Other mice and rats were present at low numbers on undisturbed sites. For example, deer mouse (*Peromyscus maniculatus*) densities were reduced by two-thirds from 1993, a peak year. Fifteen percent of *Peromyscus maniculatus* tested at two remote locations in the northern third of the NTS were positive for hantavirus antibodies. (Author) *Keywords:* climate*, perturbations*, microbiota*, mammal*, ecology/ecosystem*, life history*

629 **SAETHRE, M., and P. MEDICA. 1992. Status of Small Mammals on the NTS in 1988. In: Status of the Flora and Fauna on the Nevada Test Site, 1988. Hunter, R.B. (Compiler), DOE/NV/10630-29, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 97-160.**

Rodents are the most abundant mammals on the Nevada Test Site (NTS), and are common to all of the various habitats present on the NTS. Extensive studies on small mammal distribution, seasonal and daily activity patterns, home ranges and specific habitat preferences were undertaken by Brigham Young University (BYU) over a five year period from 1959 to 1965 (Allred et al. 1963; Jorgensen and Hayward 1965). A further review of the history of mammal sampling on the NTS is found in Hunter and Medica (1989). There are three species of lagomorphs (rabbits and hares) and over twenty species of rodents present on the NTS. Several species of rodents are found throughout most of the biotic communities on the NTS. The majority of these species have patchy distributions at low densities, occupying specific plant communities and elevations, as well as the specific biotic communities characteristic of Mojave Desert and Great Basin Desert, which merge within the NTS, providing a unique ecotonal habitat. Two species of rodents found on NTS, *Perognathus* and *Dipodomys*, may be used as indicator species of different biotic communities (Jorgensen and Hayward 1965). The sampling of small mammals by the Basic Environmental Compliance and Monitoring Program (BECAMP) in 1988 consisted of resurveys of natural populations in three major valleys, Jackass Flats (JAF001), Frenchman Flat (FRF001), and Yucca Flat (YUF001), and initial surveys on two mesas, Pahute Mesa (PAM001) and Rainier Mesa (RAM001). Resident mammals on the above monitoring plots were sampled to provide baseline data on species composition, estimated densities of the more common species, sex ratios, age distribution, and biomass, as well as to document stability of rodent populations over time in areas undisturbed by NTS activities. In addition to the baseline monitoring plots, various types of disturbances and their impact on small mammal populations were studied on subsidiary plots. The following disturbed areas were investigated: an area denuded by gophers in Mercury Valley (MER002); two sites where fires denuded the study area, one in Mid Valley (MID002) and one in Redrock Valley (RED001); a fenced study plot (ROV008) previously exposed to a cesium-137 source (^{137} Cs), and control plot (ROV007) in Rock Valley; two blast areas where aboveground nuclear tests had been conducted on towers (YUF009 and YUF013) and an adjacent waste consolidation site (YUF0ll) from which all radioactive waste and soil had recently been removed; and the area to the northeast of project Sedan in Yucca Flat (YUF016 and YUF017) which had been affected by the blast and throw-out from the 1962 underground nuclear test. Near each of the disturbed study plots, a control area was selected and sampled to document the resident species and population sizes in areas which were representative of undisturbed habitat. Locations for all of the plots sampled for mammals in 1988 are shown in Figure 4.1. Plot locations in Nevada State Grid Coordinates are listed in Appendix 3A of Section 3, "Status of Reptiles in 1988." (Authors) *Keywords:* perturbations*, mammal*, ecology/ecosystem*, life history*

630 **SANBORN, S.R. 1972. Food habits of *Sauromalus obesus obesus* on the Nevada Test Site. Journal of Herpetology 6:142-144.**

A list of identifiable plant materials from the stomachs of 26 *S. obesus* from Nye County, Nevada is given. (ABM) *Keywords:* vegetation*, reptile*, nutrition/diet*

631 **SAULS, M.L., T.P. O'FARRELL, and W.M. QUAM. 1987. Measurement of External Radiation Doses to Free-Ranging Kangaroo Rats Inhabiting Nuclear-Event Sites On The Nevada Test Site. In: *The Dynamics of Transuranics and Other Radionuclides in Natural Environments* (Howard, W.A., and R.G. Fuller, Eds.). U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV. NVO-272. December 1985, pp. 305-315.**

A study was initiated to estimate external radiation doses to kangaroo rats, *Dipodomys merriami*, living on two nuclear-event sites, T2 and SEDAN, on the U.S. Department of Energy (DOE) Nevada Test Site. Animals were fitted with specially designed collars containing 3-4 shielded and unshielded dosimeters. A total of 52 percent of the collars fitted to free-ranging animals were recovered on month later. The collaring technique proved to be useful and provided a means for obtaining accurate measurements of external radiation exposures, although neck lesions were noted in most collared animals, and disappearance of collared animals was 48 percent compared to 32 percent for uncollared controls. Kangaroo rats living 152 m from a ground zero (GZ) where four atmospheric tests were conducted between 1952-1957 received mean exposures of 290-1,270 mR/month and additional beta doses; animals within 152 m of two GZs where single atmospheric tests were conducted received 43-102 mR/month plus additional beta doses; and kangaroo rats 1524 m from the T2 GZ received gamma doses of 17-38 mR with no beta contributions. Inexplicably high readings of controls and higher variability between doses received on dosimeters placed together precluded estimating exposures to animals inhabiting other study sites near T2 and all sites near SEDAN. *Keywords:* NAEG*, mammal*, radiation*, methods*

632 **SCHAEFFER, J.R. 1968. Climatology of Tonopah Test Range, 1967. USAEC Report SC-M-68-522, 74 pp.**

The climatology of the Tonopah Test Range is described by climatic summaries of temperature, relative humidity, station pressure, precipitation, and surface winds during 1967; summaries of the same elements based on 7-year averages covering the years 1961 to 1967; and summaries of upper winds based on the years 1961 to 1967. (Author) *Keywords:* climate*

633 **SCHAEFFER, S.M., S.A. BILINGS, and R.D. EVANS. 2000. Nitrogen dynamics in an arid ecosystem in response to carbon and nitrogen addition. In: Symposium Abstracts, The Ecological Society of America 85th Annual Meeting, August 6-10, 2000, Snowbird, UT.**

Nitrogen (N) is thought to be the second most limiting resource controlling net primary production (NPP) next to water in arid and semi-arid ecosystems. Nitrogen cycling by soil microbes may be limited by carbon available to soil microbes. We investigated the effects of carbon and N additions on ammonia (NH^3) volatilization, ammonification, nitrification, and denitrification in a Mojave desert ecosystem in order to assess potential limitations of C or N to these processes. All combinations of C and N additions were made at approximately four times ambient levels at four types of locations: Under the canopies of a C_3 evergreen shrub, C_4 perennial bunchgrass, and a C_3 deciduous shrub, as well as in the interspaces.

Addition of C reduced NH^3 volatilization by 53% (from 8.49 +/- 1.10 μg $N\text{-}NH_3$ m^{-2} hr^{-1} to 4.50 +/- 0.74 μg m^{-2} hr^{-1} for plots with added C and no added C respectively) while added N, in the form of KNO_3, had no effect on volatilization. After 24 hours, ammonium (NH_4) levels were lower with C addition compared to controls (2.12 +/0.39, 0.25 +/- .25, 2.91 +/- 0.71, and 0.99 +/- 0.35, μg dry $soil^{-1}$ for control, +C, +N, and +C+N plots respectively). Soil CO_2 fluxes indicated relatively greater microbial activity with added C compared to controls (32.40 +/- 7.61, 67.64 +/- 13.70, 21.36 +/- 6.01, and 83.18 +/- 9.12, μg $C\text{-}CO_2$ m^{-2} hr^{-1} for control, +C, +N and +C+N plots respectively). Potential denitrification rates were relatively greater under plant canopies compared to interspaces (2.99 +/- 2.23, 30.34 + /- 7.13, 11.95 +/- 5.33, and 21.03 +/- 7.15, ng $N\text{-}N_2O$ g dry $soil^{-1}$ interspace, C3 evergreen, C4 bunchgrass, and C3 deciduous plots respectively). Decreases in NH_3 volatilization, NH_4 levels, and increases in soil CO_2 flux with added C suggest an increase in microbial immobilization inorganic N, and further indicate a potential C limitation for microbial activity in this arid ecosystem. By characterizing the response of the ecosystem processes to potential changes in C availability we can gain an improved understanding of the structure and function of arid ecosystem and how they may respond to various types of perturbations. (Authors) *Keywords:* FACE*, perennial plants*, microbiota*, nutrition/diet*, physiology*, ecology/ecosystem*

634 **SCHULTZ, B.W., and W.K. OSTLER. 1995. Effects of Prolonged Drought on Vegetation Associations in the Northern Mojave Desert. In: Proceedings of the Wildland Shrub and Arid Land Restoration Symposium Las Vegas, NV, October 19-21, 1993. Roundy, B.A., E.D. McArthur, J.S Haley, and D.K. Mann (Compilers). Gen. Tech. Rep. INT-GTR-315. U.S. Department of Agriculture, Forest Service; Intermountain Research Station, Ogden, UT, pp. 228-235.**

EG&G Energy Measurements initiated a study in 1991 to determine the effect a prolonged drought had on vegetation structure and composition at Yucca Mountain, Nevada. A substantial die-off apparently occurred in the low-elevation blackbrush (*Coleogyne ramosissima*) association; only 46% of the plant crowns present in 1991 were alive. The creosote/bursage (*Larrea tridentata-Ambrosia dumosa*) and creosotebush/boxthorn/hopsage (*Larrea tridentata-Lycium andersonii-Grayia spinosa*) associations, respectively, had 58% and 57%, of their plant crowns alive. The high-elevation blackbrush and the boxthorn/hopsage (*Lycium andersonii-Grayia spinosa*) associations had the most live plant crowns, 79% and 81%, respectively. Indian ricegrass (*Oryzopsis hymenoides*), desert needlegrass (*Stipa speciosa*), and shadscale (*Atriplex confertifolia*), were the species most affected by the drought; live plant crowns were 3%, 43% and 52%, respectively. Many other species had highly variable survival rates among the vegetation associations. (WKO) *Keywords:* YMSCO*, perturbations*, vegetation*, perennial plants*, life history*

635 **SCHULTZ, B.W., and W.K. OSTLER. 1995. Species and Community Response to Above Normal Precipitation Following Prolonged Drought at Yucca Mountain, Nevada. In: Proceedings of the Wildland Shrub and Arid Land Restoration Symposium Las Vegas, NV, October 19-21, 1993. Roundy, B.A., E.D. McArthur, J.S. Haley, and D.K. Mann (Compilers). Gen. Tech. Rep. INT-GTR-315. U.S. Department of Agriculture, Forest Service; Intermountain Research Station, Ogden, UT, pp. 236-342.**

EG&G Energy Measurements initiated a study in 1991 to determine how the perennial species component of vegetation associations and individual perennial plant species in the northern Mojave Desert responded to above-normal precipitation following a prolonged and severe drought. All vegetation associations had a large increase in both absolute and relative cover. Most perennial species increased in cover across all vegetation associations; however, several declined in cover on one or two associations. Plant populations did not show a similar increase in density. Only three species had a large relative or absolute increase in density, but their response was association specific. (Authors) *Keywords:* YMSCO*, perturbations*, vegetation*, perennial plants*, ecology/ecosystem*

636 **SCHULZ, R.K. 1977. Root Uptake of Transuranic Elements. In: *Transuranics in Natural Environments*. White, M.G., and P.B. Dunaway (Eds.). NVO-178, Nevada Applied Ecology Group, U.S. Energy Research & Development Administration, Las Vegas, NV, pp. 321-330.**

The uptake of elements by plant roots is one of the important pathways of entry of many elements into the food chain of man. Data are cited showing plutonium concentration ratios, plant/soil, ranging from 10^{-10} to 10^{-3}. Concentration ratios for americium range from 10^{-7} to 10^{+1}. Limited experiments with curium and neptunium indicate that root uptake of curium is similar to that of americium and that plant uptake of neptunium is substantially larger than that of curium and americium. The extreme ranges of concentration ratios cited for plutonium and americium are due to a number of causes. Experimental conditions such as very intensive cropping will lead to abnormally high concentration ratios. In some experiments, addition of chelating agents markedly increased plant root uptake of transuranic elements. Particle size and composition of the source material influenced uptake of the transuranics by plants. Translocation within the plant, and soil factors such as pH and organic matter content, all effect concentration ratios. (Authors) *Keywords:* NAEG*, radionuclide inventory*, vegetation*, nutrition/diet*, radiation*

637 **SCHULZ, R.K., and M.O. WEAVER. 1993. Tritium Migration Studies at the Nevada Test Site - Topical Report. DOE/NV-364, UC-721, Waste Management Division, U.S. Department of Energy, Las Vegas, NV.**

Emanation of tritium from waste containers is a commonly known phenomenon. Release of tritium from buried waste packages was anticipated; therefore, a research program was developed to study both the rate of tritium release from buried containers and subsequent migration of tritium through soil. Migration of tritium away from low-level radioactive wastes buried in Area 5 of the Nevada Test Site was studied. Four distinct disposal events were investigated. The oldest burial event studied was a 1976 emplacement of 3.5 million curies of tritium in a shallow land burial trench. A plot area 7 m x 14 m centered over the buried containers was established as a vegetative sampling area. Tritium transport to the atmosphere by plant transpiration was determined to have risen sharply with the passage of time to about 6 curies per year in 1990 and decreased to about 1 curie per year by 1992. In another event, 248 thousand curies of tritium was disposed of in an overpack emplaced 6 m below the floor of a low-level waste disposal pit. Measurement of the emanation rate of tritium out of 55 gallon drums to the overpack was studied, and an annual doubling of the emanation rate over a seven year period, ending in 1990, was found. During the past two years the rate of increase has slowed appreciably. No evidence of significant migration of tritium away from the overpack was found. In a third study, upward tritium migration in the soil, resulting in releases in the atmosphere were observed in a greater confinement disposal test. Here, the movement was suspected largely to be the result of experimental anomalies and heat generated by other radionuclides present in the waste. Releases of tritium to the atmosphere were found to be insignificant. The fourth event consisted of burial of 2.2 million curies of tritium in a greater confinement disposal operation. Emanation of tritium from the buried containers has been increasing since disposal, but no significant migration was found four years following backfilling of the disposal hole. (Authors) *Keywords:* vegetation*, radionuclide inventory*, radiation*

638 **SCHULZ, R.K., and M.O. WEAVER. 1995. Tritium Migration Studies at the Nevada Test Site - Topical Report. Defense Waste Branch, Environmental Restoration and Waste Management Division, U.S. Department of Energy, Las Vegas, NV.**

Emanation of tritium from waste containers is a commonly known phenomenon. Release of tritium from buried waste packages was anticipated; therefore, a research program was developed to study both the rate of tritium release from buried containers and subsequent migration of tritium through soil. Migration of tritium away from low level radioactive wastes buried in Area 5 of the Nevada Test Site was studied. Four distinct disposal events were investigated. The oldest burial event studied was a 1976 emplacement of 3.5 million curies of tritium in a shallow land burial trench. A plot area 7 m x 14 m centered over the buried containers was established as a vegetative sampling area. Tritium transport to the atmosphere by plant transpiration was determined to have risen sharply with the passage of time to about 6 curies per year in 1990 and decreased to about 0.7 curies per year by 1993. In another event, 248 thousand curies of tritium was disposed of in an overpack emplaced 6 m below the floor of a low-level waste disposal pit. Measurement of the emanation rate of tritium out of 55 gallon drums to the overpack was studied, and an annual doubling of the emanation rate over a seven year period, ending in 1990, was found. During 1991 - 1993 the rate of increase has slowed appreciably. No evidence of significant migration of tritium away from the overpack was found. In a third study, upward tritium migration in the soil, resulting in releases in the atmosphere were observed in a greater confinement disposal test. Here, the movement was suspected largely to be the result of experimental anomalies and heat generated by other radionuclides present in the waste. Releases of tritium to the atmosphere were found to be insignificant. The fourth event consisted of burial of 2.2 million curies of tritium in a greater confinement disposal operation. Emanation of tritium from the buried containers has been increasing since disposal, but so far, and over a period of six years, only trace amounts of tritium have migrated a few meters from the buried waste. Indications are, that no significant amounts of tritium, if any at all, will ever reach the soil surface and be released to the atmosphere. Also, since plant rooting depth is only a few meters in the desert, tritium discharge to the atmosphere via the plant pathway should also be zero or close to zero in the future when this area is revegetated. (Authors) Keywords: radionuclide inventory*, vegetation*, radiation*

639 **SCHULZ, R.K., E.M. ROMNEY, E.W. KENDALL, R.B. HUNTER, L.M. FUJII, and P.D. GREGER. 1991. Tritium Migration Studies at the Nevada Test Site - Topical Report. August, 1991. DOE/NV-345, UC-721, Defense Waste Branch, Environmental Restoration and Waste Management Division, U.S. Department of Energy, Las Vegas, NV, 17 pp.**

Emanation of tritium from waste containers is a commonly known phenomenon. Release of tritium from buried waste packages was anticipated, therefore a research program was developed to study both the rate of tritium release from buried containers and subsequent migration of tritium through soil. Migration of tritium away from low level radioactive wastes buried in Area 5 of the Nevada Test Site was studied. Four distinct disposal events were investigated. The oldest burial event studied was a 1976 emplacement of 3.5 million curies of tritium in a shallow land burial trench. Tritium transport to the atmosphere by plant transpiration was determined to have risen sharply with the passage of time, and is now occurring at the rate of about 6 curies per year. The tritium being released from this waste has not resulted in elevated tritium levels in the urine of people working directly on the trench cap, so this is scarcely a release rate to cause alarm. Also, air samplers placed around the perimeter of the Area 5 site show no higher tritium levels than the Nevada Test Site in general. In another event, 248 thousand curies of tritium was disposed of in an overpack emplaced 6 meters below the floor of a low-level waste disposal pit. Measurement of the emanation rate of tritium out of 55 gallon drums to the overpack was studied, and an annual doubling of the emanation rate over a seven year period was found. No evidence of significant migration of tritium away from the overpack was found. In a third study, upward tritium migration in the soil was observed in a greater confinement disposal test. Here, the movement was suspected largely to be the result of experimental anomalies and heat generated by other radionuclides present in the waste. Releases of tritium to the atmosphere were found to be insignificant. The fourth event consisted of burial of 2.2 million curies of tritium in a greater confinement disposal operation. No significant migration was found one and one-half years following backfilling of the disposal hole. (Authors) Keywords: radionuclide inventory*, radiation*

640 **SCHULTZ, V. 1966. References on Nevada Test Site ecological research. Great Basin Naturalist 26:79-86.**

The following references came to my attention while I was associated with the U. S. Atomic Energy Commission. The list has been restricted to research conducted on the area since the establishment of the Nevada Test Site. It includes papers resulting in their entirety from such efforts as well as papers covering a much broader geographical area but including data from the site. Many current reports of the U. S. Atomic Energy Commission and its associates will probably appear in the open literature at some future date. The assistance of D.M. Allred, W.E. Martin, W.A. Rhoads, W.H. Rickard, L.M. Shields and their associates in checking an earlier version of the list is gratefully acknowledged. (Author) *Keywords:* bibliography*, ecology/ecosystem*

641 **SHARP, G.T., P.E. LEDERLE, C.L. SOWELL, and M.K. COX. 1999. Survival, Movements, and Nesting Activity of Gambel's Quail at Yucca Mountain, Nevada. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00071 Rev 00. Las Vegas, NV, 10 pp.**

In support of radionuclide monitoring efforts, data on the population structure, survival, movement patterns, and nesting activity and success of Gambel's quail were collected in two areas at Yucca Mountain during 1992 and 1993. One area was located near the Exploratory Studies Facility (ESF), adjacent to the potential high-level nuclear waste repository site. The second area was located near the Well J-13 pond, 3 km southeast of the ESF area. During 1992 and 1993, 93 quail were captured during three trap sessions, with 90% of captures (84 of 93) occurring in the ESF area. Thirty-nine quail (31 from the ESF area, and 8 from the J-13 area) were fitted with radio transmitters. Of the 39 quail, 3 died and 1 was lost within 24 hours after capture. The 35 remaining quail were located a total of 431 times; 325 locations in the ESF area, and 106 in the J-13 area from March 1992 to July 19.93. Twenty-eight of 35 (80.0%) radiomarked quail died after 3 to 59 weeks of monitoring, 3 (9%) were alive at the end of the study, and 4 (11%) were unaccounted for, most likely due to the loss of transmitter signals, or unaccounted predation. Some radiomarked quail moved more than 3 km, and two moved greater than 6.5 km. In addition, one female moved between the Well J-13 and ESF areas several times. These movements suggest that the ESF and J-13 areas do not contain separate populations of quail. If radiological monitoring of quail is conducted near the proposed repository site and a control site is required, the control site should be at least 10 km from the ESF. Distances moved also suggest that there is a potential for quail to move from the Yucca Mountain area onto adjacent public land where hunting is permitted. Twelve nests were observed during the 1992 and 1993 nesting seasons (April-June). Clutch size averaged 14.1 eggs in 1992, and 13.6 eggs in 1993. Hatching success was 86% in 1992 and 98% in 1993. Because quail populations follow a "boom and bust" pattern of abundance, collecting during years following plentiful winter and spring rains should have little effect on the long-term survival of quail populations at Yucca Mountain. Trapping effort required to collect quail for radionuclide-level testing would be substantially less during years following plentiful winter and spring rains. It is recommended that sampling occur only during years when there have been average or above average amounts of rainfall during the winter and spring. Sampling should occur after July to ensure that brood rearing is over. (Authors) *Keywords:* YMSCO*, bird*, ecology/ecosystem*, life history*

642 **SHIELDS, L.M., and F. DROUET. 1962. Distribution of terrestrial algae within the Nevada Test Site. Amer. Journal of Botany 49: 547-554.**

The incidence of terrestrial algal species in natural soil growths at the Nevada Test Site was considered in relation to the major shrub zones and to atomic target areas. Observations are based upon samples collected in three successive years (1957 to 1959) from control sites in the various shrub types, at 0.1-mile intervals within 1.0 mile from five tower ground zeros, and from the vicinity of the one perennial body of water, Cane Springs. Twelve terrestrial algal species, other than diatoms, were identified by microscopic examination of natural soil growths. Four soil species appeared in culture only. Fifteen taxa occurred only in the vicinity of the one aquatic habitat. Colloidal sheaths *of Microcoleus vaginatus, Schizothrix californica* and *Schizothrix acutissima* stabilize soil particles, forming a surface crust. *Nostoc commune, Scytonema hofmannii* and *Protosiphon cinnamomeus* are commonly associated with lichens. Algal species cultured from the vicinity of nuclear detonation sites are reported. Seed plants showed a gradient of decreasing evidence of damage between 0.6 mile and the 1.0 mile interval at which vascular vegetation appeared relatively unaffected. The abundant stand of annuals the following spring between 0.3 and 0.6 mile, interpreted as evidence of seed survival in the soil, indicates that the surface crust within this radius tended to remain in position. Algae occurring as natural soil growths within 0.6 mile of ground zero the year following detonation appeared to represent survivors of nuclear effects. Algae developing only in culture may be windblown contaminants. For detonations at the five tower target areas during the 1957 nuclear test series at the Nevada Test Site, energy yields in roentgen equivalents for mammals one min after burst were approximated as ranging from 60,000 for the smallest to 700,000 for the largest shot at 0.25 mile from ground zero, 3000-30,000 at 0.5 mile and 700-6000 at 0.75 mile. While algae within 0.5 mile may have been removed with the soil or subjected to thermal injury, none at this distance were exposed to significant radiation levels. *Microcoteus vaginatus* was one of three algal species isolated from Nevada Test Site soils following acute y exposures of 1280 kR from Co-60. *M. vaginatus* has also grown on sterile and in cultures of test-site soil following acute experimental Co-60 exposures amounting to 2560 kR. This species is the first alga to colonize construction sites and roadsides in this area. The extreme aridity of the growing seasons of 1959 to 1961 may account for failure of this and other species to become reestablished on bladed control plots and at ground zeros within three yr following denuding. Failure to invade cannot be explained on the basis of radiation levels since the outer margin of the 100 mR/hr zone typically receded to within 0.5 mile of ground zero within 1 week. The effects of soil removal, denuding and-the presence of debris from fission products are reflected temporarily within the 0.4-mile radius of ground zero by a slightly higher pH and electrical conductivity and a lower Kjeldahl nitrogen than in the surrounding 0.5-1.0 mile. (BBB) *Keywords:* perturbations*, wetlands*, microbiota*, radiation*, taxonomy*

643 **SHIELDS, L.M., and W.H. RICKARD. 1961. A preliminary evaluation of radiation effects at the Nevada Test Site. In: *Recent Advances in Botany,* pp. 1387-1390.**

Field studies were conducted between 1957-1959 to determine the effects of nuclear detonations on native plant communities of the Nevada Test Site. In vegetation surviving in the vicinity of above-ground target areas, there was no unequivocal evidence of radiation damage. Radiation did not seem to damage or kill shrubs at two initial detonation sites, but it may have selectively affected germination in winter annual species. Conifers near an underground shot chamber that vented were probably killed by root damage rather than by radiation insult. (TPO) *Keywords:* perturbations*, perennial plants*, annual plants*, radiation*

644 **SHIELDS, L.M., and P.V. WELLS. 1962. Effects of nuclear testing on desert vegetation. Science 135:38-40.**

Detonation of fission-type nuclear devices results in an inner circle of complete denudation of desert shrub vegetation, often about 0.5 mi in radius, surrounded by a zone of partial and selective destruction which is variable in width. The gross injury to vegetation appears to be attributable to mechanical and thermal effects. Successional change in the composition of the vegetation, due to invasion by plants of pioneer character, is taking place in all disturbed areas. (Authors) *Keywords:* perturbations*, ecology/ecosystem*, vegetation*, perennial plants*, radiation*

645 **SHIELDS, L.M., and P.V. WELLS. 1963. Recovery of vegetation on atomic target areas at the Nevada Test Site. In: (Schultz, V., and A.W. Klement, Jr., Eds.) *Radioecology,* Proceedings of the First National Symposium on Radioecology, pp. 307-310.**

The typical nuclear detonation at the Nevada Test Site, an airburst of a 20 to 40-kiloton yield, denuded a zone of desert shrub vegetation about 0.5 mile in radius. Asymmetric blast damage to shrubs extended a greater distance, in some cases to beyond one mile, varying with species and stability of the substratum. Gross injury to vegetation appears to be largely from blast and thermal effects. The spring following denudation, ground cover by annuals between 0.4 and 0.8 mile from different ground zeros exceeded total cover in the control vegetation. Beyond the perimeter of denudation, recovery is evident in the crown sprouting of several shrub species, in the appearance of weedy perennials, and in the prominence of bunchgrasses. During a four-year study period (1957 through 1961) it has not been possible to establish an unequivocal relation between killing, injury, or morphological aberration in vegetation and ionizing radiation from nuclear detonations. (Authors) *Keywords:* perturbations*, invasive species*, annual plants*, perennial plants*, ecology/ecosystem*, radiation*

646 **SHIELDS, L.M., L.W. DURRELL, and A.H. SPARROW. 1961. Preliminary observations on radiosensitivity of algae and fungi from soils of the Nevada Test Site. Ecology 42:440-441.**

To evaluate relative radiosensitivity of soil algae and fungi from the Nevada Test Site, 89 soil samples were exposed to different levels of γ radiation from a Co-60 source. Total doses ranged from 2.5 to 2,560 kR administered at dose rates varying from 190 to 245 kR/hr. The max exposure was 320kR for the first series, 1,280 kR for the second, and 2,560 kR for the third. The soils were taken from the surface and 3- to 6-in. depth within one mile of four ground zeros and in undisturbed control areas. In both controls and treated samples, no difference in radiation injury could be observed between those from ground zeros of two years previously and those from undisturbed vegetation zones. Some soil algae were less susceptible to radiation injury than common fungi of arid soils. Three algal species survived acute exposures of 1,280 kR, but the upper range of tolerance for fungi in the same samples was 640 kR. *Microcoleus vaginatus* the algal species consistently showing the highest radioresistance, is the most abundant and widely distributed alga in semi-desert soils. Two other algal species (*Phormidium tenue* and *Synechococcus cedrorum*) survived a max of 1,280 kR. The higher soil moisture level in the control series is reflected in the isolation of a greater number of fungal taxa and the relatively low radioresistence of all species. In the 3rd series, five species grew in culture following soil dosages of 640 kR: (*Stemphylium ilicis*, *Fusarium* sp., *Phoma* sp., *Alternaria tenuis* and *Streptomyces* sp.). (BBB) *Keywords:* microbiota*, radiation*

647 **SHIELDS, L.M., P.V. WELLS, and W.H. RICKARD. 1963. Vegetational recovery on atomic target areas in Nevada. Ecology 44:697-705.**

The effects of fission-type nuclear detonations on perennial plant cover at the Nevada Test Site were studied. An account is given of denuding and recolonization, by annual species in particular, in the vicinity of seven ground zeros. Observations were made from the close of Operation Plumbbob. An airburst of a 20-kt yield denuded a concentric zone of desert shrub vegetation about 0.5 mi in radius. Selective shock and blast damage to perennials extended asymmetrically to beyond 1 mile in certain cases. During the first recovery year the area within 0.1 to 0.3 mile of ground zeros remained essentially barren until *Salsola kali* formed a widely spaced summer stand. Cover by spring annuals between 0.4 and 0.8 mile from different tower detonation points exceeded total cover in the control vegetation. One species, *Mentzelia albicaulis*, contributed the greater part of the cover within 1.0 mile of five tower sites. In the surrounding vegetation *Chaenactis stevioides* was the predominant annual. A marked decrease in the second-, third-, and fourth-year cover at target areas was associated with a less favorable climatic regime. *Chaenactis* spp. and *Bromus rubens* invaded progressively in the direction of ground zeros. Marginal to the denuded areas, certain perennials are recovering by crown sprouting, and weedy shrubs are appearing. Gross damage to vegetation beyond the perimeter of complete denudation, however, appears to be attributable to mechanical and thermal injury. Radiosensitivity of various plant species is discussed. (BBB) *Keywords:* perturbations*, invasive species*, annual plants*, perennial plants*, ecology/ecosystem*, radiation*

648 **SHINN, J.H., E.H. ESSINGTON, F.L. MILLER, Jr., T.P. O'FARRELL, J.A. ORCUTT, E.M. ROMNEY, J.W. SHUGART, and E.R. SOROM. 1989. Results of a Cleanup and Treatment Test at the Nevada Test Site: Evaluation of Vacuum Removal of Plutonium-Contaminated Soil. Health Physics Vol. 57(5):771-779.**

We have conducted experiments to evaluate the effectiveness of removing contaminated soils from the Nevada Test Site with a large truck-mounted vacuum cleaner. Our results show that this method is effective, relatively easy, and safe for equipment operators. With four passes of the truck-mounted vacuum, 92% of the ^{241}Am (and the accompanying $^{239+240}$Pu) was removed and resuspension rates were reduced by more than 99%. The ecological impact was, however, serious in terms of soil erosion and destruction of small animal habitats. Compared to standard earth-moving techniques, vacuuming permits a significant reduction in the volume of soil collected to achieve the desired level of contamination, and the volume reduction could result in cost savings for packaging, shipment, and burial. This cost savings would only be realized for projects involving decontamination of the top 5 cm of soil. *Keywords:* radionuclide inventory*, perturbations*, vertebrate*, methods*

649 SIMANTON, J.R., C.W. JOHNSON, J.W. NYHAN, and E.M. ROMNEY. 1986. Rainfall Simulation on Rangeland Erosion Plots. In: Proceedings of the Rainfall Simulator Workshop January 14-15, 1985 Tucson, AZ. Lane, L.J. (Ed.). Society for Range Management, Denver, CO, pp. 11-17.

Rainfall simulator studies on erosion plots have been made on rangelands in Arizona, Idaho, New Mexico, and Nevada. An extensive data base has been developed for various ecosystems in these western states. Because the same simulator and similar experimental design were used for all the studies, results can be easily transferred across ecosystems. The experimental design included the use of large plots (10.7 m X 3 m); 60 mm/hr rainfall rate; and natural, bare, clipped, grazed and tilled treatments. Results from these studies have been related to USLE parameters and to effects of various surface and canopy characteristics. The importance of erosion pavement on the erosion process of western arid and semiarid rangelands has been demonstrated, and, in some cases, appears to be more dominant than vegetation canopy. (Authors) *Keywords:* climate*, hydrology*, vegetation*, ecology/ecosystem*, methods*

650 SKUJINS, J. 1979. Comparison of biological processes in western deserts. US/IBP Desert Biome Res. Memo. 77--20. Utah State University, Logan, 15 pp.

Soils from the Great Basin, Sonoran, Chihuahuan and Mohave deserts were collected at certain periods throughout several seasons which would best exhibit microbial response (or lack of it) to moisture or vegetation. The soils were analyzed for several chemical and physical properties. Biological and biochemical characteristics, such as respiration, dehydrogenase activity, ATP concentration, proteolytic activity, autotrophic and heterotrophic nitrogen fixation, nitrification potential, denitrification and microbial numbers, were measured. The soils exhibited fluctuations in microbial and biochemical activities as measured by respiration, dehydrogenase activity, ATP concentration, proteolytic activity, nitrification potential and other parameters during different moisture seasons. Increase in soil moisture as modified by precipitation did not cause a significant difference in respiration or proteolysis between desert soils; however, an increase in moisture did cause a significant difference in nitrification potential of desert soils. Proteolytic activity was highest in soils collected when above-ground portions of desert plants were dormant. Low nitrification potential of desert soils was found. Nitrite accumulation was observed in perfusion experiments but not in the field. Respiration, dehydrogenase activity and ATP concentration did not respond proportionally in desert soils adjusted to different moisture levels. These results suggest that respiration, dehydrogenase activity and ATP concentration each appear to represent a different phase of microbial metabolism in desert soils. Cluster analysis was used to compare the measured soil microbiological and biochemical parameters of the four western deserts. Nitrogen fixation and ammonification explained 79.2% of the variability between sampling stations. It was found that moistening soil to -3 bars did not significantly stimulate microbial activity in these desert soils. Wetting dry soils, allowing them to dry and rewetting them stimulated parameter activities an average of 73.5% from the wetted state. Dehydrogenase activity was enhanced an average of 178% compared to the wetted state. Rewetting a soil after initial wetting and then drying apparently released organic matter and stimulated ammonification. (Author) *Keywords:* IBP*, soil property*, microbiota*, ecology/ecosystem*, physiology*

651 SMITH, D.D. 1972. Radiation surveillance of ruminants on and about the Nevada Test Site. NERC-LV-539-18, 10 pp.

The metabolism and tissue burdens of radionuclides in domestic and wild ruminants were studied. The Sr-90 levels in bones from three species of ruminants namely deer, cattle and sheep grazing on or near the Nevada Test Site showed a steady decline since the cessation of atmospheric testing in 1962. Levels of Sr-90 observed in desert bighorn sheep (*Ovis canadensis nelsoni*) ranged from 3.9-13.4 pCi/g of ash in 1964 (average of 9.7 pCi/g of ash) and from 1.0-12.0 pCi/g of ash in 1971 (average of 5.8 pCi/g of ash). Levels of gamma emitting radionuclides found in the Nevada Test Site beef herd remain low, with the liver as the edible organ containing the highest levels of radioactivity. In addition, the operation of an experimental dairy farm, the maintenance of an experimental beef herd, and the use of the dairy herd in controlled metabolism studies are discussed. (Author) *Keywords:* EPA*, mammal*, radiation*

652 **SMITH, D.D. 1973. Observations on wildlife and domestic animals exposed to the ground motion effects of underground nuclear detonations. NERC-LV539-24, 11 pp.**

Domestic animals and wildlife were frequently observed or intentionally stationed in close proximity to surface ground zero at the time of underground nuclear detonations at the Nevada Test Site and at other test locations within the contiguous United States. Subjective summaries are given of large animal involvement with specific nuclear events. It is noted that physical damage from ground motion has not been reported. Recommendations are made for experimental verification of these subjective observations. (Author) *Keywords:* EPA*, perturbations*, vertebrate*, radiation*

653 **SMITH, D.D., and V.E. ANDREWS. 1981. Selected Radioisotopes in Animal Tissues in Nevada: ^{90}Strontium and ^{137}Cesium Measurements from 1956 to 1977. EPA-600-38-1027, U.S. Environmental Protection Agency, Washington, DC. DOE/NV Accession # NV0083209.**

Since 1956 the Animal Investigation Program (AIP) has been conducting surveillance of domestic and wild animals on and around the Nevada Test Site (NTS) and assessing the radionuclide burdens present in their tissues and any resulting pathological effects. Other AIP objectives were to investigate alleged dosage to animals, to maintain public information contacts with the off-site population, and to conduct special ad hoc investigations. Most of the radionuclide burden data and the AIP's history and evolution have been published in the annual reports of this program. Additional unpublished data were gleaned from the AIP historical files. This rather substantial body of radiological data has been reviewed and analyzed for trends with time and source of exposure. Because of the volume of data, only a summary has been included in the appendices of this report. The correlation of strontium-90 in the bones of young ruminants on and near the NTS with annual global fallout rates indicates that close-in fallout was not a significant long term source of strontium-90. Desert bighorn sheep from the northern portions of the hunt areas, particularly from 1972 on, exhibit higher concentrations of strontium-90 in bone than those from the southern areas. While this observed difference may be due to a higher uptake by plants of strontium-90 deposited in the northern portion from close-in fallout, it may also be due to higher annual rainfall with its associated higher annual deposition of worldwide fallout. Analysis of strontium-90 data for desert bighorn sheep as a function of age showed that the controlling factor in bone concentration was the exposure which occurred during the period of maximum bone growth, up to one year of age. Subsequent intake has some effect, but much less. The same analysis showed an effective half-life for strontium-90 in desert bighorn sheep of about 4.8 years. Comparable data for humans yielded effective half-lives of 2.7 and 4.3 years for two population groups. The results of this study of the data collected indicate that proximity to the NTS has had very little long-term impact on animals from the standpoint of uptake of either strontium-90 or cesium-137. A discussion and summary statements are provided concerning maximum hypothetical annual dose to man consuming edible tissue from animals exposed to fallout on the NTS and cesium-137 dose due to continuously deposited world-wide fallout. Histopathological examinations of tissue and lesion samples, and analysis of blood samples from the animals used in this long-term study have revealed no effects which could be attributed to exposure to radioactive materials. (Authors) (CAW) *Keywords:* EPA*, mammal*, physiology*, radiation*

654 **SMITH, D.D., and D.E. BERNHARDT. 1979. Animal Investigation Program: Nevada Test Site and Vicinity Annual Report, 1979. EPA/600/3-81-035. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Las Vegas, NV, 72 pp.**

Data are presented from the radioanalyses of tissues collected from cattle, mule deer, desert bighorn sheep, rabbits, chukar, golden eagles, and other wildlife that resided on or near the Nevada Test Site during 1979. Routine and special activities of the Animal Investigation Program are also discussed. Other than the naturally occurring potassium-40, gamma-emitting radionuclides were detected infrequently. Strontium-90 concentrations in bones from deer, cattle, and desert bighorn sheep were lower than those of recent years. Tritium concentrations were generally within expected environmental limits with the exception of animals exposed to known sources of contamination; e.g., drainage ponds from Area 12 tunnels or the Sedan Crater. Plutonium levels in all tissues from all species showed little variation to those levels in samples collected in recent years. Radionuclide tissue concentrations were generally higher in the tissues of animals residing in Area 15 than in similar animals collected from other Nevada Test Site areas. Hypothetical annual dose estimates to man were calculated on the basis of the daily consumption of 0.5 kilogram of liver or muscle from animals that contained peak radionuclide levels. The movements of 25 mule deer outfitted with collars containing a radio transmitter unit were monitored on a weekly basis. No gross or microscopic lesions were found in necropsied animals that could be directly attributed to the effects of ionizing radiation. (Authors) *Keywords:* EPA*, mammal*, bird*, nutrition/diet*, radiation*

655 **SMITH, D.D., and S.C. BLACK. 1984. Animal Investigation Program for the Nevada Test Site: 1957-1981. EPA 600/6-84-020, DOE/DP/0539-050. Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Las Vegas, NV, 69 pp.**

This report summarizes the findings of the animal investigation program from its initiation in 1957 to termination in 1981. The program estimated the effects of nuclear testing at the Nevada Test Site on domestic and wild animals residing on, and in the vicinity of the test site. Claims of injury to animals were investigated and a routine program of collecting samples were the principle activities. Tissue samples collected were examined histopathologically and were analyzed for specific radionuclides. Analysis of tissue samples from the Nevada Test Site beef herd occurred semiannually over the entire 25-year period and several other beef herds were analyzed for up to 10-year periods. Other animals sampled for extended periods included mule deer and desert bighorn sheep. The results of the claims investigations are reported as well as analysis for the radionuclides: Tritium, strontium-90, iodine-131, cesium-137, and plutonium-239. Also, the results of certain special studies, e.g. in animals around other testing sites such as Mississippi, Colorado, etc., and for special purposes such as at the Rocky Flats plant in Colorado, and for iodine-129 in thyroids from Nevada cattle in hypothetical doses to man from ingestion of edible tissue are included. (Authors) *Keywords:* EPA*, mammal*, nutrition/diet*, radiation*

656 **SMITH, D.D., and K.R. GILES. 1970. Animal Investigation Program, 1969 annual report. SWRHL-102r, 20 pp.**

The radionuclide contents of selected bovine, deer, and Bighorn sheep tissues which were collected during 1969 from animals grazing on or near the Nevada Test Site are reported. The radionuclide burden remains low, with the highest levels and widest range reported from animals collected in May. The strontium content of bones collected from all three species continues the downward trend of recent years. Other activities of the Animal Investigation Program during 1969 are also mentioned. Tables are presented to show contents of Ce-144, Cs-137, I-131, K-40, Mn-54 Ru-106, Sr-89, and Sr-90. (Authors) *Keywords:* EPA*, mammal*, nutrition/diet*, radiation*

657 **SMITH, D.D., and K.R. GILES. 1974. Animal Investigation Program, 1970 annual report. NERC-LV-539-16, 53 pp.**

This report presents the radionuclide contents of tissues collected during 1970 from cattle, deer, desert bighorn sheep, and other wildlife on or near the Nevada Test Site (NTS). Gamma emitting radionuclides were infrequently detected in the tissues of animals living on or around the NTS. However, I-131 was detected in the thyroids of all beef animals sampled during October. The probable source of the I-131 was a non-U.S. atmospheric test conducted on October 14, 1970. Elevated levels of I-131, Ru-106, H-3 were detected in the tissues of wildlife that drank from drainage ponds that collect runoff waters from the mines used for testing activities. A man, eating 311 g of the flesh on one chukar sampled, would ingest 34.2 nCi of I-131 and 53 uCi of H-3. The average Sr-90 levels detected in the bones of three ruminant species sampled on and around the NTS ranged from 2.4 to 5.6 pCi/g of ash. These levels are lower than those reported during 1969 and reflect the downward trend observed since the cessation of atmospheric testing. No gross or microscopic lesions were detected that could be directly attributed to the effects of ionizing radiation. Details of special studies of wildlife utilizing the contaminated runoff waters, of cattle grazing in the Schooner fallout area, and surveillance activities associated with Project Rulison are also presented. Other activities of the Animal Investigation Program including claim investigation, public information displays, etc., during 1970 are described. (Authors) *Keywords:* EPA*, bird*, mammal*, nutrition/diet*, radiation*

658 **SMITH, D.D., and K.R. GILES. 1975. 1971 Animal Investigation Program Annual Report. NERC-LV-539-20, National Environmental Research Center, U.S. Environmental Protection Agency, Las Vegas, NV, 39 pp.**

This report presents the data obtained from the radioanalysis of tissues collected from cattle, deer, desert bighorn sheep, and other wildlife that reside on or near the Nevada Test Site. Cesium-137 and ^{106}Ru were the only gamma-emitting radionuclides detected in the soft tissues of range cattle. Ruthenium-106 was detected only in the lungs of animals sampled in May. Strontium-90 levels in the cattle femurs ranged from Z to 37 ρCi/g of ash. The latter value was found in the bones of a 14-year-old cow that had lived on the Nevada Test Site her entire life. The bones of the same animal also had the highest level of ^{239}Pu (46 ρCi/g of ash) that was reported. Analysis of her 8-month-old fetus revealed the presence of detectable levels of ^{239}Pu which indicates placental transfer of this radionuclide. The average ^{90}Sr levels in the bones from deer and desert bighorn sheep were 3.2 and 4.7 ρCi/g of ash, respectively. Elevated levels of ^{106}Ru and ^{3}H were found in the tissues of two mule deer collected near the drainage ponds that collect runoff waters from mines used for nuclear testing activities. Other animals sampled included Golden eagles, feral horses, coyotes, and chukar. The ^{137}Cs levels in an eagle collected during 1964 varied only slightly from one collected during 1971. No gross or microscopic lesions were detected that could be attributable to the effects of ionizing radiation. Other activities of the Animal Investigation Program, including special studies, investigations, and public information displays, are described. (Authors) *Keywords:* EPA*, bird*, mammal*, nutrition/diet*, radiation*

659 SMITH, D.D., and K.R. GILES. 1983. Animal Investigation Program 1981 Annual Report: Nevada Test Site and Vicinity. EPA-600/3-83-014, U.S. Environmental Protection Agency, 64 pp.

Data are presented from the radioanalysis of tissues collected from animals that resided on or near the Nevada Test Site (NTS). Other than naturally occurring potassium-40, cesium-137 was the only gamma-emitting radionuclide frequently detected and was within a narrow range of activity. For example, 12 of 14 cattle muscle samples contained 15 - 65 ρCi of cesium-137 per kilogram. Strontium-90 and plutonium-238 or -239 tissue concentrations were similar to those of recent years. Nanocurie levels of tritium were found in tissue from two deer that drank contaminated water draining from the tunnel test areas. Annual dose estimates to man were calculated based on the daily consumption 0.5 kg of tissue with peak radionuclide levels. The highest postulated dose was millirems to the whole body from ingestion of deer muscle that drank from the tritium contaminated waters. This dose is about 9% of the radiation protection guide. Movement of deer on the NTS is discussed. In general, deer from Pahute Mesa winter in the Timber Mt. area with some movement off the NTS, while deer from Rainier Mesa winter in the Shoshone Mt. area. The sudden death of an offsite goat kid was investigated and death was attributed to enterotoxemia. No gross or microscopic lesions in necropsied animals were found that could be attributed to the effect of ionizing radiation. (Authors) *Keywords:* EPA*, mammal*, nutrition/diet*, radiation*

660 SMITH, D.D., D.E. BERNHARDT, and K.R. GILES. 1980. Animal Investigation Program 1978 Annual Report: Nevada Test Site and Vicinity. DOE/DP/0059-038. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Las Vegas, NV, 64 pp.

Data are presented from the radioanalysis of tissues collected from cattle and wildlife that resided on or near the Nevada Test Site. Gamma-emitting radio-nuclides were detected infrequently with the exception of short-lived radionuclides found in samples from animals collected soon after a nuclear test by the People's Republic of China. Plutonium and Strontium-90 concentrations in tissues from deer, cattle, and desert bighorn sheep were consistent with those of recent years. Tritium concentrations were generally within expected environmental limits with the exception of animals exposed to sources of contamination. Radionuclide tissue concentrations were generally higher in the tissues of animals residing in Area 15 than in similar animals collected from other Nevada Test Site areas. Hypothetical dose estimates to man were calculated on the basis of the daily consumption of 0.5 kilogram of liver or muscle from animals that contained peak radionuclide levels. The highest postulated dose was 1.4 millirems for tritium in tissues from a mule deer. The movements of 13 mule deer outfitted with collars containing a radio transmitter unit were monitored on a weekly basis. During the winter deer left their summer range and migrated 40 to 60 kilometers south and west. A deer originally captured in 1977 was killed by hunters approximately 120 kilometers from its capture point. No gross or microscopic lesions were found in necropsied animals that could be directly attributed to the effects of ionizing radiation. (Authors) *Keywords:* EPA*, mammal*, nutrition/diet*, radiation*

661 SMITH, D.D., K.R. GILES, and D.E. BERNHARDT. 1976. Animal Investigation Program 1972 Annual Report. NERC-LV-539-35, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Las Vegas, NV, 82 pp.

This report presents the data obtained from the radioanalyses of tissues collected from cattle, deer, desert bighorn sheep, and other wildlife that reside on or near the Nevada Test Site. Also discussed are special actinide studies with cattle from the Tonopah Test Range and Searchlight, Nevada, special sampling of an Arizona buffalo herd, and bioenvironmental sampling of the Gnome site in New Mexico and the Tatum Dome Test Site in Mississippi. The thyroids of cattle sampled during May and deer sampled in March and May contained detectable levels of ^{131}I. The possible source of this radionuclide was an atmospheric nuclear detonation in the People's Republic of China during March. Cesium-137 and ^{95}Zr were the only gamma-emitting radionuclides that were regularly detected in the soft tissues. Cesium-137 was found in ten beef muscle and two beef liver samples. The median values were 30 and 28 ρCi/kg, respectively. On Nevada Test Site deer muscle sample had a level of 24 cPi/kg while muscle samples from Mississippi deer contained 2300 and 3100 ρCi/kg. Elevated tritium levels were found in three cattle, one deer, and a coyote. Postulated sources of these levels are discussed. The ^{90}Sr levels in bones or ruminants continued the downward trend of recent years. Cattle bones average 3.9 ρCi/g ash, deer 3.1 ρCi/g ash, and desert bighorn sheep 4.9 ρCi/g ash. The analysis of tissues for actinides was emphasized during 1972. Levels of ^{239}Pu detected in muscle of beef cows ranged from 0.5% to 4% of the levels found in the ingests. These levels in the bones tended to increase with age of the animal. Hypothetical dose estimates resulting from the daily consumption of liver or muscle containing peak activity levels were calculated using the minimum guide of 0.5 rem per year fro the whole body. These estimates expressed as a percent or 0.5 rem were: ^{3}H, 0.12%; ^{137}Cs, 0.11%; ^{203}Hg, 1.8%; U natural, 0.04%; ^{238}Pu, 0.007%; and ^{239}Pu, 0.15%. Gross and microscopic lesions found in sampled animals are discussed. The most significant lesions reported were anthracotic-like pigments in a coyote's lung and a bile duct carcinoma in a horse. Food habits of desert bighorn sheep were determined through the botanical analysis of rumen contents. The average composition of the ingesta was 65% grasses, 34% shrubs, and 1% forbs. Other activities of the Animal Investigation Program are described. These include special studies, investigation surveys, and public information activities. (Authors) *Keywords:* EPA*, mammal*, nutrition/diet*, radiation*

662 SMITH, D.D., K.R. GILES, and D.E. BERNHARDT. 1977. Animal Investigation Program 1973 Annual Report: Nevada Test Site and Vicinity. U.S. Environmental Protection Agency, 112 pp.

Data are presented form the radioanalysis of tissues collected from cattle, deer, desert bighorn sheep, and other wildlife that resided on or near the Nevada Test Site during 1973. Routine activities and special investigations of the animal investigation program are also discussed. Iodine-131 was detected in the thyroid of a Nevada Test Site mule deer. The postulated source was worldwide fallout from nuclear detonation conducted by the People's Republic of China. Other than the naturally occurring potassium-40, cesium-137 was the only gamma-emitting radionuclide detected with any consistency in soft tissues. Nine muscle samples from the Nevada Test Site beef herd contained levels of cesium-137 ranging from 14 to 50 ρCi/kilogram. Muscle from two deer contained 20 and 30 ρCi/kilogram. Rabbit muscle contained 200 ρCi/kilogram and muscle from a feral horse contained 40 ρCi/kilogram. Tritium levels in all animal tissues sampled were at background except for animals residing at the Area 15 farm and for a feral horse. Postulated sources of these exposures are discussed. The strontium content in bones continued the downward trend observed during recent years. Bones from grazing beef cattle averaged 3.2 ρCi/gram of ash, deer bones averaged 2.7 ρCi/gram of ash, and bones from desert bighorn sheep averaged 4.1 ρCi/gram of ash. Tissue samples also were analyzed for actinides because of the intense interest in their environmental fate. The appendices of this report list the concentrations of plutonium-238 and -239, and uranium-234, -235, and -238 found in each tissue from each animal sampled. Also discussed are possible reasons for some seemingly anomalous results. The detectable levels of plutonium-239 in muscle from four beef cattle ranged form 0.25 percent to 0.8 percent of that reported for their ingesta. The relationship between liver (six animals) and ingesta was more variable, with a range of 0.13 percent to 32 percent. Hypothetical dose estimates to man are calculated on the basis of the daily consumption of liver or muscle from the Nevada Test Site animals that contained peak activity levels. These estimates expressed as a percent of 0.5 rem are: for whole body--tritium, 0.02 percent and cesium-137, 0.11 percent; and for the gastrointestinal tract--ruthenium-103, 0.14 percent. The percentage doses for bone are: total uranium, <0.01 percent; plutonium-238, 0.02 percent; and plutonium-239, 0.03 percent. The apparently anomalous results are excluded from these estimates. The dietary habits of desert bighorn sheep were determined through botanical analyses of rumen contents. The average composition of the ingesta was: grasses, 61.3 percent; shrubs, 31.1 percent; forbs, 7.6 percent. Gross and microscopic lesions found in necropsied animals are discussed. In general, these lesions are consistent with the physical condition of the animal and type of population sampled. (Authors) *Keywords:* EPA*, mammal*, nutrition/diet*, radiation*

663 SMITH, D.D., K.R. GILES, and D.E. BERNHARDT. 1981. Animal Investigation Program 1979 Annual Report: Nevada Test Site and Vicinity. DOE/DP/00539-042, U.S. Environmental Protection Agency, 65 pp.

Data are presented from the radioanalyses of tissues collected from cattle, mule deer, desert bighorn sheep, rabbits, chukar, golden eagles, and other wildlife that resided on or near the Nevada Test Site during 1979. Routine and special activities of the Animal Investigation Program are also discussed. Other than the naturally occurring potassium-40, gamma-emitting radionuclides were detected infrequently. Strontium-90 concentrations in bones from deer, cattle, and desert bighorn sheep were lower than those of recent years. Tritium concentrations were generally within expected environmental limits with the exception of animals exposed to known sources of contamination; e.g., drainage ponds from Area 12 tunnels or the Sedan Crater. Plutonium levels in all tissues from all species showed little variation to those levels in samples collected in recent years. Radionuclide tissue concentrations were generally higher in the tissues of animals residing in Area 15 than in similar animals collected from other Nevada Test Site areas. Hypothetical annual dose estimates to man were calculated on the basis of the daily consumption of 0.5 kilogram of liver or muscle from animals that contained peak radionuclide levels. The highest postulated dose was 2.6 millirems to bone for plutonium-238 in liver obtained from a mule deer. This dose is about 0.5 percent of the 500 millirems per year radiation protection guide for individuals in the general population. All other postulated doses for consumption of the tissue containing other radionuclides are about 0.3 percent or less of the standard. The movements of 25 mule deer outfitted with collars containing a radio transmitter unit were monitored on a weekly basis. During the winter months, all deer left their summer range on the mesas of the Nevada Test Site. However during 1979, the deer were dispersed over the widest area observed since 1975. Several deer wintered on the Nellis Bombing and Gunnery Range to the north and one wintered near Black Mountain. A deer captured in December 1979 was observed 7 months later in the Barley Creek area of Nye County which is approximately 160 kilometers from its capture point. No gross or microscopic lesions were found in necropsied animals that could be directly attributed to the effects of ionizing radiation. (Authors) *Keywords:* EPA*, bird*, mammal*, nutrition/diet*, ecology/ecosystem*, radiation*

664 SMITH, D.D., K.R. GILES, and D.E. BERNHARDT. 1982. Animal Investigation Program 1980 Annual Report: Nevada Test Site and Vicinity. U.S. Environmental Protection Agency, 64 pp.

Data are presented from the radioanalysis of tissues collected from cattle, mule deer, desert bighorn sheep, rabbits, and a horse that resided on or near the Nevada Test Site during 1980. Routine and special activities of the animal investigation program are also discussed. Other that the naturally occurring potassium-40, gamma-emitting radionuclides were detected infrequently. Iodine-131 was found in the thyroid of a deer 3 weeks after a nuclear test by the People’s Republic of China. Strontium-90 concentrations in bones from deer, cattle, and desert bighorn sheep were similar to those of recent years. Radionuclide concentrations were generally higher in the tissues of animals residing in area 15 than in similar animals collected from other Nevada Test Site areas. Surface soil samples from the Area 15 farm contained

plutonium-238 and 239 in nanocurie per kilogram concentrations. (Authors) *Keywords:* EPA*, radionuclide inventory*, mammal*, nutrition/diet*, radiation*

665 SMITH, D.D., P.A. MEDICA, and S.R. SANBORN. 1987. Ecological comparison of sympatric populations of sand lizards (*Cophosaurus texanus* and *Callisaurus draconoides*). Great Basin Naturalist Memoirs 47(2):175-85.

Sympatric populations of *Cophosaurus texanus* and *Callisaurus draconoides* were periodically sampled from March 1973 through April 1974 at Burro Creek, Mohave County, Arizona. *Callisaurus* were also sampled at Rock Valley, Nye County, Nevada. Sex ratios were skewed in favor of males in the adult *Cophosaurus* but were equal in both adult populations of *Callisaurus*. Both species became sexually mature as yearlings. Mean clutch sizes were 3.55 (±0.83) for *Cophosaurus*, and 4.25 (±1.08) and 5.07 (±1.33) for *Callisaurus* at Burro Creek and Rock Valley respectively. Evidence of multiple clutches was exhibited by both species. Egg weight/body weight ratios for both species and clutch weight/body weight ratios for *Cophosaurus* were notably smaller than previously reported. At Burro Creek both species were highly insectivorous, with orthopterans comprising the largest food group of each. Niche overlap for food was high at the ordinal level, but at the familial level it is apparent that *Callisaurus* probably fed in the more xeric areas of the riparian habitat. No differences were found in the temperature responses of these two lizards. However, minor temporal separations and substantial spatial partitioning were observed. *Callisaurus* preferred sandy open areas, while *Cophosaurus* preferred the presence of some rocks and boulders. (Authors) *Keywords:* reptile*, ecology/ecosystem*, life history*, nutrition/diet*

666 SMITH, D.D., K.R. GILES, D.E. BERNHARDT, and K.W. BROWN. 1977. Animal Investigation Program 1974 Annual Report: Nevada Test Site and Vicinity. EMSL-LV-0539-10. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Las Vegas, NV, 37 pp.

Data are presented from the radioanalysis of tissues collected from cattle, deer, desert bighorn sheep, and other wildlife that resided on or near the Nevada Test Site during 1974. Routine activities and special investigations of the Animal Investigation Program are also discussed. Other than the naturally occurring potassium-40, gamma-emitting radionuclides are detected infrequently. For example, cesium-137 is found only in the muscle tissues from 3 of the 12 Nevada Test Site cattle sampled during 1974. Tritium concentrations in the tissues from most of the animals sampled are at background levels. Animals from the experimental farm tended to have slightly higher concentrations than those sampled at other locations on the Nevada Test Site. Strontium-90 levels in bones from deer, desert bighorn sheep, and cattle are slightly lower than those reported for the preceding year. A graph depicts the average levels found in the bones of the three species from 1956 through 1974. The appendices of this report list actinide concentrations (plutonium-238, plutonium-239, uranium-234, uranium-235, and uranium-238) found in the tissues of all animals sampled. Graphs compare the plutonium-239 levels in lungs, livers, and femurs from Nevada Test Site cattle for the years 1971 through 1974. Levels reported appear to be relatively constant for these years with bone and lung data being nearly identical each year. Concentrations in liver are generally a factor of 2 or 3 lower than values for bone and lung. Hypothetical dose estimates to man are calculated on the basis of the daily consumption of 0.5 kilogram of liver or muscle from Nevada Test Site animals that contained peak activity levels. The highest postulated dose is 0.6 millirem from cesium-137 in muscle from an aged beef cow. All other postulated doses from other radionuclides are less than 0.1 millirem, except for a plutonium-239 concentration in liver from a range cow. The dietary habits of desert bighorn sheep are determined through botanical analysis of rumen contents and are discussed according to the geographical locations of the animals at time of collections. In general, grasses made up about 60 percent of the diet with approximately 25 percent provided by shrubs and the remainder coming from forbs. Gross and microscopic lesions found in necropsied animals are discussed. In general, these lesions are consistent with the physical condition of the animal and type of population sampled. No gross or microscopic lesions were detected that could be directly attributed to the effects of ionizing radiation. (Authors) *Keywords:* EPA*, mammal*, nutrition/diet*, radiation*

667 **SMITH, D.D., K.R. GILES, D.E. BERNHARDT, and K.W. BROWN. 1978. Animal Investigation Program 1975 Annual Report: Nevada Test Site and Vicinity. EMSL-LV-0539-14. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Las Vegas, NV, 45 pp.**

Data are presented from the radioanalysis of tissues collected from cattle, deer, desert bighorn sheep, and other wildlife that resided on or near the Nevada Test Site during 1975. Routine activities and special investigations of the Animal Investigation Program are also discussed. Other than the naturally occurring potassium-40, gamma-emitting radionuclides are detected infrequently. Tritium concentrations in the tissues from most of the animals sampled are at background levels. Strontium-90 levels in bones from deer and cattle are slightly lower than those reported for the preceding year while levels in desert bighorn sheep bones were elevated. A graph depicts the average levels found in the bones of the three species from 1956 through 1975. The appendices of this report list actinide concentrations (plutonium-238, plutonium-239, uranium-234, uranium-235, and uranium-238) found in the tissues of all animals sampled. Graphs compare the plutonium-239 levels in lungs, livers, and femurs from Nevada Test Site cattle for the years 1971 through 1975. Levels reported appear to be relatively constant for these years with bone and lung data being nearly identical each year. Concentrations in liver are generally a factor of 2 or 3 lower than values for bone and lung. Hypothetical dose estimates to man are calculated on the basis of the daily consumption of 0.5 kilogram of liver or muscle from Nevada Test Site animals that contained peak activity levels. The highest postulated dose is 2.2 millirems from plutonium-239 in liver from a mule deer. All postulated doses from other radionuclides are less than 1 millirem, except for cesium-137 in muscle from a mule deer. All of these postulated doses are less than 1 percent of the 500 millirems/year guide for radiation doses to the general population. A deer migration study was initiated with the successful capture of eight mule deer which were outfitted with radiotransmitter-equipped collars, then released, and their movements followed on a weekly basis. A number of Nevada Test Site springs were renovated to provide cleaner and more dependable water sources for wildlife. The dietary habits of desert bighorn sheep were determined through the botanical analysis of rumen contents and are discussed according to the geographical locations of the animals at time of collections. In general, grasses made up about 50 percent of the diet with approximately 45 percent provided by shrubs and the remainder coming from forbs. The gross and microscopic lesions found in necropsied animals are discussed. In general, these lesions are consistent with the physical condition of the animal and type of population sampled. No gross or microscopic lesions were detected that could be directly attributed to the effects of ionizing radiation. (Authors) *Keywords:* EPA*, wetlands*, mammal*, nutrition/diet*, ecology/ecosystem*, radiation*

668 **SMITH, D.D., K.R. GILES, D.E. BERNHARDT, and K.W. BROWN. 1978. Animal Investigation Program 1976 Annual Report: Nevada Test Site and Vicinity. EMSL-LV-0539-20. U.S. Environmental Protection Agency, Las Vegas, NV, 111 pp.**

Data are presented from the radioanalysis of tissues collected from cattle and mule deer, desert bighorn sheep, feral horses, and other wildlife that resided on or near the Nevada Test Site during 1976. Routine activities and special investigations of the animal investigation program are also discussed. Other than the naturally occurring potassium-40, gamma-emitting radionuclides were detected infrequently with the exception of iodine-131 in animal thyroid samples collected after September 25 (the date of a nuclear test by the People's Republic of China). Strontium-90 concentrations from deer, cattle, and desert bighorn sheep continued the downward trend of recent years. Tritium concentrations were generally within ambient limits with the exception of animals exposed to sources of contamination; e.g., Sedan crater, drainage ponds from area 12 tunnels, etc. Analysis of actinide in tissues was emphasized during 1976. Graphs illustrate the plutonium-239 levels in lungs, livers, and femurs from Nevada Test Site beef cattle for the years 1971 through 1976. Femur and lung residue data are nearly identical for each year with liver concentrations being a factor of 2 or 3 lower. Hypothetical dose estimates to man were calculated on the basis of the daily consumption of .5 kilogram of liver or muscle from animals that contained peak actinide levels. The highest postulated dose was 11 millirem from tritium from tissues for a mule deer. This dose is about 2 percent of 500 millirems/year guide for radiation doses to an individual in the general public. All other postulated doses for consumption of the tissue containing other radionuclides are less than .1 percent of this guide. The food habits of desert bighorn sheep were discussed according to the geographic locations of the animals at time of collection. Grasses made up approximately 60 percent of the diet at all locations, with shrubs content approaching 30 percent and the remainder consisting of various forbs. The movement of 13 mule deer fitted with collars containing a radiotransmitter unit was monitored on a weekly basis. During the winter months, several deer did not leave the general area of their original capture while others moved over 50 kilometers to the Timber Mountain area. No gross or microscopic lesions were found in necropsied animals that could be directly attributable to the effect of ionizing radiation. *Keywords:* EPA*, mammal*, nutrition/diet*, ecology/ecosystem*, radiation*

669 SMITH, D.D., K.W. BROWN, R.A. BRECHBILL, K.R. GILES, and A.L. LESPERANCE. 1972. The radionuclide concentrations and botanical composition of the diet of cattle grazing the Area 18 range of the Nevada Test Site, 1966-1970. SWRHL-110r, 31 pp.

The radionuclide content and botanical composition of the diet of the cattle grazing on Area 18 range of the Nevada Test Site was determined by analyzing rumen samples collected from fistulated steers. A value for November 26, 1969 of 22 nCi/g was found that could be the result of ingestion of a single particle by the grazing animal. The radionuclide concentrations of the rumen samples both from world-wide fallout and from NTS events were either below the minimum detectable amount or are of very low magnitude. No pathology has been found that can be attributed to radiation. Detectable levels of Zr-95, Ru-106, Ba-140 and Ce-144 were usually found in samples collected during the late spring and early summer. Levels of Ru-106 and Zr-95 persisted into the fall. Samples collected following a contaminating event usually showed I-131 and Ba-140. Grass was a major portion of the diet. Squirreltail grass and Indian rice grass were predominant. Galleta grass, the dominant grass in Area 18 appeared in large amounts in June 1966, July 1967, July, August, September 1968 and in September 1969. Desert bitterbush and gambel oak were the principal browse species during most months. (HP) *Keywords:* EPA*, mammal*, nutrition/diet*, radiation*

670 SMITH, D.D., A.B. CROCKETT, D.E. BERNHARDT, K.R. GILES, and R.R. KINNISON. 1979. Animal Investigation Program 1977 Annual Report: Nevada Test Site and Vicinity. EMSL-LV-0539-26. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Las Vegas, NV, 37 pp.

Data are presented from the radioanalysis of tissues collected from cattle, mule deer, desert bighorn sheep, rabbits, feral horses, and other wildlife that resided on or near the Nevada Test Site during 1977. Routine activities and special investigations of the Animal Investigation Program are also discussed. Other than the naturally occurring potassium-40, gamma-emitting radionuclides were detected infrequently with the exception of short-lived radionuclides found in samples from animals collected after September 21 (the date of a nuclear test by the People's Republic of China). Strontium-90 concentrations in bones from deer, cattle, and desert bighorn sheep continued the downward trend of recent years. Tritium concentrations were generally within expected environmental limits with the exception of animals exposed to sources of contamination, e.g., Sedan Crater, drainage ponds from Area 12 tunnels. Radionuclide tissue concentrations were generally higher in the tissues of animals residing in Area 15 than in similar animals collected from other Nevada Test Site areas. Statistical analyses were made of plutonium-239 levels reported in cattle tissue collected from 1971 through 1977. These data are displayed graphically and reveal that activity levels in lungs, liver, and bone are significantly related to the age of the cattle. Activity levels did not change significantly in the ingesta and lungs during this time period but did tend to increase for bone and liver. Activity levels in the ingesta are significantly higher in the fall than in the spring. Hypothetical dose estimates to man were calculated on the basis of the daily consumption of 0.5 kilogram of liver or muscle from animals that contained peak radionuclide levels. The highest postulated dose was 8.6 millirems for tritium in tissues from a mule deer. This dose is about 2 percent of the 500 millirems per year radiation protection standard for individuals in the general population. All other postulated doses for consumption of the tissue containing other radionuclides are about 0.1 percent or less of this guide. The movements of 17 mule deer outfitted with collars containing a radiotransmitter unit were monitored on a weekly basis. During the winter months, all deer left their summer range on the mesas of the Nevada Test Site and migrated 40 to 60 kilometers south and west to Timber Mountain or south to Shoshone Mountain. Three of the animals left the Nevada Test Site in the Beatty Wash area. A statistical estimate was made of the Nevada Test Site deer population in selected areas utilizing the marked deer as a basis for this estimate. These estimates were 82 deer in the Echo Peak area, 32 in the Dead Horse Flats area, 10 in Area 20, and 43 in the Rainier Mesa area. No gross or microscopic lesions were found in necropsied animals that could be directly attributed to the effects of ionizing radiation. (Authors) *Keywords:* EPA*, mammal*, nutrition/diet*, ecology/ecosystem*, radiation*

671 **SMITH, H.D., C.D. JORGENSEN, and H.D. TOLLEY. 1972. Estimation of small mammal density using recapture methods: Partitioning of estimator variables (sic). Acta Theriologica 17:57-66.**

A model was designed to estimate small mammal densities using capture-recapture data. It includes a grid design with dense perimeter traps to detect movements off and on the grid. If movement is detected, dispersal behavior, death rate, trap avoidance, and animal-trap relationships are determined and partitioned to provide reliable density estimates. If movement is undetectable, the density estimates are less reliable. Reliable estimates of density are provided without home range data. This model seems to be most useful in studies where permanent or semi-permanent grids are established in populations that cannot be disturbed by removal or killtrapping. (TPO) *Keywords:* mammal*, ecology/ecosystem*, methods*

672 **SMITH, M.H., B.G. MAZA, and J.G. WIENER. 1980. Social Interaction and Spatial Distribution in a Desert Rodent. Journal of Mammalogy 61(1):113-116.**

The objective of this study was to measure the response of an enclosed population of long-tailed pocket mice (*Perognathus formosus*) to experimental removal of individuals and their subsequent reintroduction at the location of removal. The study was conducted at Rock Valley within a 12 by 12 grid placed in the center of a 8.92-ha circular enclosure. The mobility of non-captured animals was altered by removal trapping on the grid. Many individuals rapidly moved from the periphery of the enclosure to the center. Subsequent reintroduction of captured animals into the enclosure did not significantly alter their centers of activity relative to their baseline measures indicating that individual *P. formosus* had moved back to their original areas of activity. The response by nonresident animals to the void created by the removal of grid residents was rapid. When later released with the original residents, nonresident animals quickly assumed their former peripheral locations whereas the residents reestablished within the grid. Thus, the spatial organization was apparently dependent upon the social interaction among animals. Competition for space and associated resources is probably a prerequisite for the evolution of such a system. (CAW) *Keywords:* mammal*, ecology/ecosystem*

673 **SMITH, S.D., C.A. HERR, K.L. LEARY, and J.M. PIORKOWSKI. 1995. Soil-plant Water Relations in a Mojave Desert Mixed Shrub Community: A Comparison of Three Geomorphic Surfaces. Journal of Arid Environments (29):339-351.**

Comparative plant water relations and soil moisture content of three geomorphic surfaces were assessed in a northern Mojave Desert mixed shrub community. The adjacent geomorphic surfaces studied were an ephemeral wash (Wash), a dissected alluvial fan remnant (Bench), and a montane slope (Slope). Perennial vegetation transpired for 2-6 months during a typical precipitation year. Plant water relations differed between species (on the same geomorphic surface) and between surfaces (for the same species). Plant water stress was greatest on the Bench, which had the finest textured soils and was underlaid by an indurated petrocalcic layer. Plants from the Wash and Slope sites had higher water potentials and stomatal conductances, presumably due to coarser textured, deeper soils in the Wash and water storage in fractured bedrock on the Slope. Soil water uptake patterns closely approximated relative transpiration on each surface. No evidence of deep percolation below the rooting zone was found on any of the three surfaces during a normal rainfall year. The study site was located just outside the north-west corner of the Yucca Mountain study area. (Authors) *Keywords*: YMSCO*, geology*, hydrology*, soil property*, perennial plants*, physiology*

674 **SMITH, S.D., T.E. HUXMAN, R.W. NOWAK, and S.F. ZITZER. 1999. Responses of a Mojave Desert ecosystem to elevated CO_2: Results from the Nevada Desert FACE Facility. Annual Meeting, California Academy of Sciences, Fullerton, CA, April 30.**

The Nevada Desert FACE Facility (NDFF) is a state-of-the-art research facility at the Nevada Test Site designed to study responses of a Mojave Desert ecosystem to increased atmospheric CO_2 FACE stands for Free Air CO_2 Enrichment, which allows the CO_2 content of the air surrounding vegetation to be continuously increased while keeping all other conditions natural. Desert FACE consists of an array of study plots, each 25 m in diameter, at elevated CO_2 concentration (550 ppm) and ambient CO_2 concentration (360 ppm). The study site is located on a broad alluvial fan in vegetation that is dominated by *Ambrosia dumosa* (bursage) and *Larrea tridentata* (creosotebush). Current predictions are that the productivity of desert ecosystems will increase by about 50% with double atmospheric CO_2; this predicted increase for deserts is greater than for any other ecosystem type. Predictions also suggest that plant water loss may be reduced at elevated CO_2, thereby enhancing soil moisture content during the potential growing season. Preliminary results from the NDFF during a drought year in 1997 and a wet El Niño year in 1998 suggest that photosynthesis and plant productivity do indeed increase at elevated CO_2 whereas leaf-level transpiration rates decline. Observed increases were greatest in dry seasons, not during times of high resource availability. These early results indicate that we will need a longer term data set during both wet and dry years before we can determine how elevated CO_2 may affect landscape water balance in a Mojave Desert ecosystem. (Authors) *Keywords:* FACE*, perturbations*, perennial plants*, ecology/ecosystem*, physiology*

675 SMITH, S.D., K. LEARY, C. HERR, and S. HOKETT. 1990. Water relations and transpiration of native vegetation in the vicinity of Yucca Mountain, NV, pp. 250-55. In: Proceedings of the Symposium on Cheatgrass Invasion, Shrub Die-off, and Other Aspects of Shrub Biology and Management. McArthur, E.D., E.M. Romney, S.D. Smith, and P.T. Tueller (Eds.), Las Vegas, NV, April 5-7, 1989. Gen Tech. Rep. INT-276. USDA Forest Service, Ogden, UT.

The water relations and transpiration of native vegetation, and the role of vegetation in vadose zone hydrology, have been assessed for three geomorphic surfaces over 2 years in the vicinity of Yucca Mountain, NV. The adjacent geomorphic surfaces were: (1) an ephemeral wash termed the Wash site; (2) a dissected alluvial fan remnant, termed the Bench site; and (3) a steep, shallow-soiled, rocky, mountain slope termed the Slope site. The following methods were employed: (1) characterization of vegetation structure, leaf area, and seasonal activity patterns of the dominant shrub species on each site; (2) assessment of water relations parameters of each shrub species and the role of vegetation in site evapotranspiration using steady state porometry and paired vegetated/cleared plots; and (3) measurement of volumetric water content in the vadose zone using Time Domain Reflectometry. Results to date indicate that the potential recharge "mass zero-flux plane" is located between 25 and 125 cm, and is deepest in the Wash site. Over a 2-year period, the vegetation was found to transpire for only 4 to 6 months of the year, from mid-February to mid-June and in response to late summer rainfall. Plant water relations parameters differed significantly between species and between geomorphic surfaces. Plant transpiration accounted far about 33 percent of annual precipitation input for the site as a whole, and was highest in the Wash site. (Authors) *Keywords:* YMSCO*, climate*, hydrology*, vegetation*, ecology/ecosystem*, physiology*

676 SMITH, S.D., R.S. NOWAK, J.R. SEEMANN, and D. JORDAN. 1997. The Nevada Desert FACE Facility (NDEF): Description and Early Results. Bulletin of the Ecological Society of America 78(4):188.

The NDFF initiated carbon dioxide fumigation in the winter of 1987 in a Mojave Desert scrub ecosystem located on the DOE Nevada Test Site. Three study plots of undisturbed vegetation were exposed to 550µL/L atmospheric carbon dioxide using FACE technology with two sets of control plots. The extreme environments of desert biomes represent one end of a spectrum of predicted responses to elevated atmospheric CO_2. Primary production in desert ecosystems has been predicted to increase dramatically at elevated CO_2, but It is not clear how important feedbacks such as drought and soil nitrogen will influence long-term production processes at high CO_2. In FACE experiments, it is possible to examine responses and feedbacks up to the landscape scale. Physiological responses of existing desert vegetation to a step increase in atmospheric CO_2 are reported along with a summary of environmental factors currently under a long term monitoring program. (Authors) *Keywords:* FACE*, perturbations*, climate*, hydrology*, vegetation*, ecology/ecosystem*, physiology*

677 SMITH, S.D., T.E. HUXMAN, S.F. ZITZER, T. CHARLET, and C. GRANT. 1999. Stimulation of primary productivity in a Mojave Desert ecosystem by elevated CO_2: A comparison of estimation methods at the Nevada Desert FACE Facility. In: Symposium Abstracts, The Ecological Society of America 84th Annual Meeting, August 8-12, 1999, Spokane, WA.

The Mojave Desert is the most arid region of North America and is predicted to be one of the biome types most responsive to rising $CO_{2.}$ Increased carbon gain and water use efficiency are predicted to occur such that primary production stimulation of 50% has been predicted. This is a key hypotheses being tested at the Nevada Desert FACE Facility (NDFF), an ecosystem manipulation in the Mojave Desert. Productivity estimates were made at the NDFF in 1998, an unusually wet year. The annual plant community showed up to 40% increases in individual plant and plot-level aboveground production. Perennial plant cover and canopy incremental growth showed larger in creases at elevated CO_2 during this wet year. Leaf-level analysis (incremental growth on marked shoots) showed increases in growth, and these increases were proportional to increases in both leaf area and woody biomass. Thus, plant adjustments in allocation did not occur; growth increases were instead a function of increased total plant cover. Litter production, which should be a reasonable estimate of total aboveground production in this system, indicated a strong increase in litterfall per unit perennial canopy volume at elevated $CO_{2.}$ While we estimated up to 50-60% higher aboveground production at elevated CO_2 in this water-limited system, the degree of increase varied with methodology, suggesting that longer periods of study under a variety of rainfall regimes will be necessary before firm estimates can be made. (Authors) *Keywords:* FACE*, perturbations*, annual plants*, perennial plants*, ecology/ecosystem*, physiology*

678 SMITH, S.D., T.E. HUXMAN, S.F. ZITZER, T.N. CHARLET, D.C. HOUSMAN, J.S. COLEMAN, L.K. FENSTERMAKER,

J.R. SEEMANN, and R.S. NOWAK. 2000. Elevated CO_2 increases productivity and invasive species success in an arid ecosystem. Nature 408:79-82.

Arid ecosystems, which occupy about 20% of the earth's terrestrial surface area, have been predicted to be one of the most responsive ecosystem types to elevated atmospheric CO_2 and associated global climate change. Here we show, using free-air CO_2 enrichment (FACE) technology in an intact Mojave Desert ecosystem, that new shoot production of a dominant perennial shrub is doubled by a 50% increase in atmospheric CO_2 concentration in a high rainfall year. However, elevated CO_2 does not enhance production in a drought year. We also found that above-ground production and seed rain of an invasive annual grass increases more at elevated CO_2 than in several species of native annuals. Consequently, elevated CO_2 might enhance the long-term success and dominance of exotic annual grasses in the region. This shift in species composition in favor of exotic annual grasses, driven by global change, has the potential to accelerate the fire cycle, reduce biodiversity and alter ecosystem function in the deserts of western North America. (Authors) *Keywords:* FACE*, perturbations*, climate*, invasive species*, annual plants*, perennial plants*, ecology/ecosystem*, physiology*

679 **SMITH, T.M., A.L. LESPERANCE, V.R. BOHMAN, R.A. BRECHBILL, and K.W. BROWN. 1968. Intake and digestibility of forages grazed by cattle on a southern Nevada range. Proceedings, Western Section, Amer. Soc. of Animal Science 19:77-282.**

Rumen fistulated steers were used to sample forage on a northern desert shrub range in southern Nevada during the winter, early summer and late summer. Grass made up 98 and 100 percent of the diet during the winter and early summer periods, respectively. During the late summer period Russian Thistle (*Salsola kali*) accounted for 78 percent of the selected diet. Percentages of the fibrous portions of the selected diet either were not significantly (P less than .01) different between periods or decreased with each succeeding period. Conversely, crude protein was highest during the two summer periods. Digestibility of dry matter, crude protein, gross energy, crude fiber and NFE was significantly (P less than .05) higher in either the late summer or both summer periods. Total digestible nutrient content was significantly (P less than .05) higher only in the late summer period. Percent digestible protein was (P less than .01) lowest in the winter period while percent digestible energy showed no significant (P greater than .05) difference between periods. Intake of digestible protein increased significantly (P less than .01) with each period. Dry matter and TDN intake was highest (P less than .05) in the late summer period. Digestible energy intake was significantly (P less than .05) different between the winter and late summer periods. (Authors) *Keywords:* perennial plants*, invasive species*, annual plants*, mammal*, nutrition/diet*

680 **SOHOLT, L.F., and W.K. IRWIN. 1976. The Influence of Digging Rodents on Primary Production in Rock Valley, 1975. Progress Report (Final). US/IBP Desert Biome Res. Memo. 76-18. Utah State University, Logan, 10 pp.**

The goal of this study was to analyze the effects of rodent burrowing upon soil conditions and plant growth. Information form the literature suggested to us that burrowing activity would improve the soil conditions for plant growth. Burrowing did increase the proportion of sands and silts in the soils. Rodents deposited soil on the surface and avoided moving rocks to the surface. This activity led to the loosening of the soil as reflected by the lower bulk densities. This loosening resulted in faster rates of water infiltration into the burrowed soils that into the unburrowed soils. However, lower bulk density also resulted in faster drying of the soil. Although burrowing activity does affect the soils, it probably is of little ecological significance. The plants have a greater effect upon the soils and the extent of burrowing is limited in the habitat. The burrowing activities of rodents did decrease annual densities to about 65% of the densities on unburrowed soil The faster drying of burrowed soil undoubtedly led to a lower survival of annuals. However, only a small proportion of the annual populations would be affected by burrowing. Contrary to our initial expectations, burrowing had negative upon the growth of perennials. The effect was not statistically significant. (Authors) *Keywords:* IBP*, soil property*, annual plants*, perennial plants*, mammal*, ecology/ecosystem*

681 **SOHOLT, L., M.R. GRIFFIN, and L. BYERS. 1975. The influence of digging rodents on primary production in Rock Valley. US/IBP Desert Biome Res. Memo. 75-19. Utah State University, Logan, 9 pp.**

The objective of this study was to evaluate the impact of rodent burrowing upon soil conditions and plant growth. Recent burrowing activity affects less that 5% of the ground surface. However, signs of old, weathered activity suggest that, over the long term, burrowing affects a considerably larger percentage of the ground surface. Over one-third of the perennials were found to have burrowing activity beneath them. Rodents tended to prefer larger shrubs, with open bases as sites for burrows. There was a slight trend for finer soil particles and lower bulk density in burrowed soils than found in unburrowed soils. This trend was much less than expected from the literature. Water infiltration into the soil was increased by burrowing activity and by the presence of a shrub. In the open, burrowing activity doubled the infiltration rate. Burrowing had little effect beneath shrubs. Evaluation of the effects of rodents upon plant growth was hindered by the poor growth during the study period. *Ambrosia dumosa* was the only shrub that exhibited even a slight response to the rodents: growth was lower than in control plants. This response may have been due to browsing by gophers and ground squirrels. Artificial burrowing resulted in no inhibition or enhancement of growth. It is quite evident that when plant growth is low, rodent activity has little influence. (Authors) *Keywords:* IBP*, soil property*, perennial plants*, mammal*, ecology/ecosystem*

682 SOWELL, C.L., and J.L. BOONE. 1996. Lagomorph Population Trends at Yucca Mountain, Nevada: 1990-1995. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00053 Rev 00. Las Vegas, NV, 11 pp.

Project personnel studied lagomorphs (jackrabbits and cottontail rabbits) because these species could provide baseline data on radionuclide body burdens in animals at Yucca Mountain. If hunted, contaminated lagomorphs could provide a pathway for radionuclides to enter the human food chain. However, lagomorph abundance at Yucca Mountain was thought to be low, and whether these populations were sufficiently large to support repeated harvests for radiological monitoring was unknown. In 1990, project biologists tested two methods (daytime and nighttime surveys) to assess lagomorph abundance. Nighttime-spotlight surveys were successful, and these surveys were conducted on the east and west sides of Yucca Mountain from 1990 to 1995. During 1992, 1993, and 1994, lagomorphs were numerous, but during 1990, 1991, and 1995, abundance was low and harvest would have been difficult and expensive. The number of jackrabbits seen per kilometer of road fluctuated from a low of 0.01 in 1991 to a high of 1.5 in 1994, before declining to fewer than 0.4 in 1995. Jackrabbit populations on the east and west sides of Yucca Mountain generally fluctuated in synchrony, and six other nocturnal species generally fluctuated with jackrabbits. Although populations fluctuated greatly, correlations between precipitation and abundance were high. Therefore, historic precipitation records could be used to predict periods of high abundance, and therefore efficient times to harvest lagomorphs. (Authors) *Keywords*: YMSCO*, mammal*, ecology/ecosystem*

683 SPAULDING, W.G. 1985. Vegetation and Climates of the Last 45,000 Years in the Vicinity of the Nevada Test Site, South-Central Nevada. U.S. Geological Survey, Professional Paper - 1329.

Major changes in the climate of the Nevada Test Site have occurred during the last 45,000 years. Understanding this climatic variability is important in assessing the region's suitability for permanent nuclear-waste repositories. Future climatic changes probably will occur within the time the waste materials are hazardous. The nature and magnitude of previous fluctuations indicate the nature of future climatic change that may impact on a nuclear waste repository. Reconstructions of past vegetation are used to infer climatic conditions during the past 45,000 years. Plant macrofossils from ancient packrat (*Neotoma* spp.) middens provide the data for these analyses. Middens can be older than 50,000 years, and they are common in the region. Each contains abundant mummified plant fossils, representing the plant species growing within about 30 meters of the site. Radiocarbon-dated midden samples provide detailed records of climate-induced vegetation change. During the Wisconsin glacial age, from at least 45,000 years ago to about 10,000 years ago, juniper (*Juniperus osteosperma*) woodland was widespread below elevations of 1,800 meters in the desert lowlands. Steppe shrubs were common, as were shrubs typical of the drier phases of current woodland. Late Wisconsin subalpine conifer woodland, typified by limber pine (*Pinus flexilis*), occurred at elevations above about 1,800 meters. Plants that are sensitive to frigid temperatures, and those restricted to moist habitats, are missing or are very rare in the glacial-age macrofossil record. (Author) *Keywords:* YMSCO*, climate*, perennial plants*, vegetation*, mammal*, ecology/ecosystem*

684 SPAULDING, W.G. 1990. Vegetational and Climatic Development of the Mojave Desert: The Last Glacial Maximum to the Present. In: *Packrat Middens: The Last 40,000 Years of Biotic Change*, Betancourt, J.l., T.R. Van Devender, and P.S. Martin (Eds.), University of Arizona Press, Tucson, AZ.

In this chapter, the author examines responses of plant species and associations to climatic change since the last glacial maximum as determined by fossil samples from packrat middens from the Mojave Desert. Samples include isolated middens from numerous southern and northern Mojave Desert sites in California and Nevada including middens on and near the Nevada Test Site from the Specter Range, Point of Rocks, Fortymile Canyon, Spotted Range, and Eleana Range. Consistent variations (trends) in the relative abundance of plant species in a chronosequence of macrofossil assemblages presumably reflect real changes in local vegetation. The author assumes that these plant macrofossil assemblages allow reasonable characterization of local vegetation at the community-type or “series” level. Despite some infidelity in the midden-vegetation relationship, different community types . . . leave different plant macrofossil records. Variations in these records, then, are the basis for inferring variations in the type of vegetation occurring at a given site. The author's goal is to present a detailed view of vegetation change in the Mojave Desert and its mountains. (CAW) *Keywords:* YMSCO*, climate*, vegetation*, ecology/ecosystem*

685 **SPAULDING, W.G. 1994. Paleohydrologic Investigations in the Vicinity of Yucca Mountain: Late Quaternary Paleobotanical and Palynological Records. NWPO-TR-022-94, Dames & Moore, Inc., Las Vegas, NV.**

The primary objective of this research in the vicinity of the proposed Yucca Mountain Nuclear Waste Repository is the detection of episodes of increased runoff and groundwater discharge in this presently arid area. Ancient, inactive spring deposits in nearby valley bottoms, evidence for perennial water in presently dry canyons, and recent claims for extraordinary increases in precipitation during the last glacial age (Forester, 1994), provide good reason to further investigate both lowland spring-discharge habitats, and upland drainages. The ultimate purpose is to assess the long-term variability of the hydrologic system in the vicinity of Yucca Mountain in response to naturally occurring climatic changes. An understanding of this variability is important to an assessment of the performance of the proposed Yucca Mountain Repository, because it is reasonable to anticipate that pluvial climates (those characterized by significant and persistent increases in rainfall) will occur again within its design life (10,000 to 100,000 years; National Research Council, 1992). On one hand, if no evidence of exceptional increases in runoff and discharge is found, it would be considered a favorable finding from the point of view of hydrologic stability. On the other hand, if evidence is found for perennial water in currently-dry drainages, such as Fortymile Canyon on the west flank of Yucca Mountain, it would indicate that, at the least, provisions for substantially increased recharge rates, ground-water travel fumes, and instability of drainage systems need to be made. The data generated in the course of this study are derived from radiocarbon dated packrat (*Neotoma*) middens. This report presents the results of an initial assessment of the hydrologic stability of the candidate area based on a limited suite of middens from localities that, on geomorphic and hydrologic grounds, could have been close to ancient stream-side or spring environments. Such riparian habitats have a distinctive flora composed of plants adapted to persistent, near-surface water (hydrophilic plants or phreatophytes). In the rugged terrain of the Candidate Area it is possible to locate midden sites near canyon bottoms and paleospring sites. Today these habitats are, almost without exception, dry water courses or barren valley-bottom inselbergs. However, at certain times in the past, conditions were quite different. (Authors) *Keywords:* YMSCO*, climate*, hydrology*, wetlands*, mammal*, vegetation*, ecology/ecosystem*

686 **STARKWEATHER, P. 1995. Modern and Paleolimnology of the Endorheic Playas of the Nevada Test Site, Final Report to the DOE. Report #DE-FC08-93NV11399, University of Nevada, Las Vegas, NV.**

The specifics of contemporary playa limnology for Frenchman and Yucca Lakes on the NTS are discussed. Data are presented on winter precipitation, air temperatures, physical/chemical water measures, and plankton samples taken in February 1995 when the playas were inundated due to heavy precipitation. In both playas, the dominant taxon sampled was the anostracan crustacean *Branchinecta mackini*. In Yucca Lake, but not in Frenchman, a second congeneric species, *Branchinecta gigas* was found but must be rare. Archived samples of plankton collected from Frenchman Lake in August 1964 (provided by Dr. Richard Hunter) showed three additional species of plankton not found in the February 1995 samples. This may indicate a characteristic summer versus winter community of plankton for NTS playas. (CAW) (Authors) *Keywords:* invertebrate*, climate*, hydrology*, wetlands*, invertebrate*, ecology/ecosystem*, taxonomy*

687 **STEEN, D.C., D.B. HALL, P.D. GREGER, and C.A. WILLS. 1997. Distribution of the Chuckwalla, Western Burrowing Owl, and Six Bat Species on the Nevada Test Site. DOE/NV/11718-149. Bechtel Nevada, Las Vegas, NV, 73 pp.**

Field surveys were conducted in 1996 to determine the current distribution of several animal species of concern on the Nevada Test Site (NTS). They included the chuckwalla (*Sauromalus obesus*), western burrowing owl (*Speotyto cunicularia*), and six species of bats; namely, the pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens*), spotted bat (*Euderma maculatum*), small-footed myotis (*Myotis ciliolabrum*), long-eared myotis (*M. evotis*), fringed Myotis (*M. thysanodes*), and long-legged Myotis (*M. volans*). Chuckwallas and their scat were found in rocky areas on the southern one-third of the NTS. The northern boundary of their distribution corresponded roughly with the northern boundary of the distribution of the desert tortoise on the NTS. Western burrowing owls were found in dry, open areas with flat to gradually sloping terrain in most of the major valleys on the NTS. Nearly two-thirds of the burrows found were manmade and usually consisted of partially buried pipes and culverts with an open end at ground level. The technique of playing back the primary call of the male burrowing owl was an effective technique and increased known locations of burrowing owls on the NTS by 23 percent. Six bat species of concern were captured during this survey. The spotted bat was captured for the first time on the NTS. A total of 145 individuals of bat species of concern were captured during the 1996 field study. The highest diversity of mist-netted bats was found in the Great Basin Desert region of the NTS. The pale Townsend's big-eared bat, spotted bat, and long-eared myotis were found exclusively in the Great Basin Desert region. The fringed myotis was found in the Great Basin and Mojave Desert regions, while the longlegged myotis was found in the Mojave, Mojave/Great Basin Transition, and Great Basin Desert regions. The U.S. Department of Energy, Nevada Operations Office, takes certain management actions to protect and conserve the chuckwalla, western burrowing owl, and bats on the NTS. These actions are described. (Authors) *Keywords:* sensitive animals*, bird*, reptile*, mammal*, ecology/ecosystem*

688 **STETZENBACH, L.D. 1993. Identification of Subsurface Microorganisms at Yucca Mountain: Second Quarterly Report, October 1, 1993 - December 31, 1993. Harry Reid Center for Environmental Studies, University of Nevada, Las Vegas.**

Bacteria isolated from ground water samples from 31 springs during 1993 were processed according to the protocol described in the April 1993 quarterly report. This protocol specified aseptic collection in sterile screw-capped containers, transportation on ice to the HRC microbiology laboratory, and culture by spread plating onto R2A medium. The isolates were further processed for identification using a gas chromatographic (GC) method based on the Microbial Identification System (MIDI) software obtained from Microbial ID, INC., Newark, DE. This work generated a presumptive identification of 113 bacterial species distributed among 45 genera. (Authors) *Keywords:* YMSCO*, geology*, wetlands*, microbiota*, ecology/ecosystem*, taxonomy*

689 **STETZENBACH, L.D. 1993. Identification of Subsurface Microorganisms at Yucca Mountain. Fourth Quarterly Report. Harry Reid Center for Environmental Studies, University of Nevada, Las Vegas, NV.**

Bacteria isolated from water samples collected in a series of ground water springs have been isolated, enumerated, and identified from twenty six sites. Ten sites were sampled in Death Valley, California and sixteen sites were sampled in Ash Meadows, Nevada. Replicate samples were collected and tested from four locations. All water samples were collected in conjunction with the HRC chemistry group conducting ground water fingerprinting studies. The protocol for collection of samples, as described in the 3rd quarterly report, specified aseptic collection in sterile screw-capped containers and transportation on ice to the HRC microbiology laboratory. All samples were inoculated by spread plating onto R2A (Difco Laboratories, Detroit, MI) bacterial culture medium. the R2A plates were then incubated at 28(degrees) for 5--7 days and colonies wee counted with the aid of a grid template and magnifying lens. (Author) *Keywords:* YMSCO*, geology*, wetlands*, microbiota*, taxonomy*, ecology/ecosystem*

690 **STETZENBACH, L.D. 1994. Identification of Subsurface Microorganisms at Yucca Mountain - 3rd Quarterly Report, January 1, 1994 - March 31, 1994. DOE/NV/10872–T110. Harry Reid Center for Environmental Studies, University of Nevada, Las Vegas, NV.**

Bacteria isolated from ground water samples taken from 31 springs during 1993 were collected and processed according to procedures described in earlier reports. These procedures required aseptic collection of surface water samples in sterile screw-capped containers, transportation to the HRC microbiology laboratory, and culture by spread plating onto R2A medium. The isolates were further processed for identification using a gas chromatographic analysis of fatty acid methyl esters (FAME) extracted from cell membranes. This work generated a presumptive identification of 113 bacterial species distributed among 45 genera using a database obtained from Microbial ID, Inc., Newark, Delaware (MIDI). (Authors) *Keywords:* YMSCO*, geology*, wetlands*, microbiota*, taxonomy*, ecology/ecosystem*

691 **STETZENBACH, L.D. 1994. Identification of subsurface microorganisms at Yucca Mountain. 4th Quarterly Report, April 1, 1994-June 30, 1994. DOE/NV/10872-T134, Harry Reid Center for Environmental Studies, University of Nevada, Las Vegas, NV.**

This progress report details the identification of bacteria in ground water samples from 29 springs at Ash Meadows and Death Valley. (Author) *Keywords:* YMSCO*, geology*, wetlands*, microbiota*, taxonomy*, ecology/ecosystem*

692 **STETZENBACH, L.D. 1994. Identification of Subsurface Microorganisms at Yucca Mountain - Quarterly Report, July**

1, 1994 - September 30, 1994. DOE/NV/10872-T140, Harry Reid Center for Environmental Studies, University of Nevada, Las Vegas, NV.

Bacteria isolated from ground water samples taken from springs at Yucca Mountain during 1993 were collected and processed. Three bacterial genera commonly found in water (Pseudomonas, Hydrogenophaga, and Alteromonas) were selected for extensive review during this quarter. The presence of bacteria representative of these genera in samples from the 18 springs sampled in Ash Meadows and from 14 springs in Death Valley was reviewed. The species level of identification of the three bacterial genera in water samples from the springs were examined by cluster analysis to see how much variation existed within a given species and also to determine if a species with essentially the same FAME pattern was isolated from several springs. (Author) *Keywords:* YMSCO*, geology*, wetlands*, microbiota*, taxonomy*, ecology/ecosystem*

693 **STETZENBACH, L.D. 1994. Identification of Subsurface Microorganisms at Yucca Mountain - 4th Quarterly Report. DOE/NV/10872–T69, Harry Reid Center for Environmental Studies, University of Nevada, Las Vegas, NV.**

Bacteria isolated from water samples collected in a series of ground water springs have been isolated, enumerated, and identified from twenty six sites. Ten sites were sampled in Death Valley, California and sixteen sites were sampled in Ash Meadows, Nevada. Replicate samples were collected and tested from four locations. All water samples were collected in conjunction with the HRC Chemistry group conducting ground water fingerprinting studies. The protocol for collection of samples, as described in the 3rd quarterly report, specified aseptic collection in sterile screw-capped containers and transportation on ice to the HRC microbiology laboratory. All samples were inoculated by spread plating onto R2A (Difco Laboratories, Detroit, MI) bacteria culture medium. The R2A plates were then incubated at 28° for 5-7 days and colonies were counted with the aid of a grid template and magnifying lens. (Authors) *Keywords:* YMSCO*, geology*, wetlands*, microbiota*, taxonomy*, ecology/ecosystem*

694 **STETZENBACH, L.D. 1995. Identification of Subsurface Microorganisms at Yucca Mountain - Quarterly Report, July 1, 1995 - September 30, 1995. Harry Reid Center for Environmental Studies, University of Nevada, Las Vegas, NV.**

More than 1,100 bacterial isolates were obtained over a two year period from 31 springs in a region along the southern boarder of California and Nevada. Water samples were collected from 17 springs in Ash Meadows National Wildlife Refuge and 14 springs in Death Valley National Park. Bacteria isolated from these samples were subjected to extraction and gas chromatography to determine the cellular fatty acid profile of each isolate. Fatty acid methyl esters (FAME) extracted from cell membranes were separated and classified using the Hewlett Packard by gas chromatography. The FAME profiles of each isolate were then subjected to cluster analysis by the unweighted pair-group method using arithmetic averages. During this quarter the relatedness of FAME patterns of bacterial isolates were examined at the genus level by counting the number of clusters produced in a MIDI dendrogram at a Euclidian distance of 25. This information was then used to determine microbiological relationships among springs. (Author) *Keywords:* YMSCO*, geology*, wetlands*, microbiota*, taxonomy*, ecology/ecosystem*, methods*

695 **STEVENS, S.E., and K.T. CHUNG, 1991. Physiologically anaerobic microorganisms of the deep subsurface - Progress report, June 1, 1990-May 30, 1991. DOE/ER/60991-T1, Memphis State University, TN, 16 pp.**

This study seeks to determine numbers, diversity, and morphology of anaerobic microorganisms in 15 samples of subsurface material from the Idaho National Engineering Laboratory, in 18 samples from the Hanford Reservation and in 1 rock sample from the Nevada Test Site; set up long term experiments on the chemical activities of anaerobic microorganisms based on these same samples; work to improve methods for the micro-scale determination of in situ anaerobic microbial activity; and to begin to isolate anaerobes from these samples into axenic culture with identification of the axenic isolates. (Authors) *Keywords:* geology*, microbiota*, taxonomy*, ecology/ecosystem*, methods*

696 **STORY, S.P., P.S. AMY, C.W. BISHOP, and F.S. COLWELL. 1995. Bacterial transport in volcanic tuff cores under saturated flow conditions. Biomicrobiology Journal 13:249-264.**

An antibiotic-resistant bacterium was tested for transport through volcanic tuff and sandstone cores. Tuff cores were representative of the geology of Rainier Mesa located on the Nevada Test Site (NTS). Rapid bacterial transport occurred in some of the tuff cores and all sandstone cores under the hydraulic heads used (5-500 cm). Hydraulic conductivity of the tuff cores ranged widely, 9.6 X 10^{-5} to 1.2 X 10^{-3} cm h^{-1}. A much narrower range was observed for sandstone cores, 1.6 X 10^{-2} to 5.9 X 10^{-2} cm h^{-1}, which served as experimental controls. The percentage of the initial bacterial inoculum recovered within 3 pore volumes from tuff and sandstone cores ranged from 9.4 to 54.7% and 0.20 to 2.9%, respectively. Bacterial recovery appeared to be controlled by the structure of the flow paths in rock cores and not by overall hydraulic conductivity. Saturated clay-infiltrated and unfractured zeolitized tuff cores were impermeable to water flow, and therefore bacterial transport was not detected. Three routes of bacterial transport were discerned in permeable rock cores by comparison of the breakthrough patterns of bacteria and tracer solution (chloride ions) in cores of differing lithologies. In sandstone cores, where water flowed evenly through the matrix, bacteria were transported in a dispersed manner throughout the sandstone, whereas bacteria were transported primarily along preferred flow paths (fractures or macropores) in permeable tuff cores. (Authors) *Keywords:* geology*, hydrology*, microbiota*, ecology/ecosystem*, methods*

697 STROJAN, C.L., D.C. RANDALL, and F.B. TURNER. 1987. Relationship of Leaf Litter Decomposition Rates to Rainfall in the Mojave Desert. Ecology 68(3):741-744.

Leaf litter decomposition rates were studied in Rock Valley at the NTS from 1976 to 1977. Two grams of leaves from three species were put in mesh bags and placed in the field. Bags were recovered at 6 wk intervals for 54 wks. Initial mass loss was rapid and by the end of the study period approximately 50% (ranged from 42-63%) of the dry biomass was lost. These rates are comparable to decomposition rates for leaf litter reported in arid environments. Rates of mass loss were positively correlated with measured rainfall. (WKO) *Keywords:* climate*, microbiota*, ecology/ecosystem*, nutrition/diet*

698 STROJAN, C.L., F.B. TURNER, and R. CASTETTER. 1979. Litterfall from Shrubs in the Northern Mojave Desert. Ecology 60(5):891-900.

Plant litter was collected in traps from 8 to 10 replicates each of *Ambrosia dumosa, Ephedra nevadensis, Krameria parvifolia, Larrea tridentata, Lycium andersonii*, and *Lycium pallidum* in Rock Valley, southern Nevada, USA. Collectors were made at biweekly to monthly intervals from 1975 to 1977 and hand sorted into leaves, stems, flowers, and fruits. *Lycium pallidum* produced the most litter, with annual means ranging from 52 to 173 g per shrub. Annual means per shrub for other species ranged from 39 to 89 g (*Lycium andersonii*), to 27 to 77 g (*Larrea tridentata*), 29 to 29 g (*E. nevadensis*), 6 to 18 g (*K. parvifolia*), and 3 to 21 g (*A. dumosa*). Litter fall was generally correlated with annual rainfall, which was low in 1975 (62 mm), high in 1976 (223 mm), and close to the long-term mean in 1977 (141 mm). Leaves were generally the largest litter category, followed by stems, fruits, and flowers. Large sample variations were found, particularly for reproductive parts. Aboveground litter fall from the six species, which comprise ≈82% of perennial plant biomass and ≈81% of shrub cover in Rock Valley, was about 117 kg/ha in 1975 and 318 kg/ha in 1976. Total aboveground litter fall for Rock Valley (all perennial and annual plants) was estimated to be 194 kg/ha in 1975 and 530 kg/ha in 1976. Distinct litter fall patterns occurred for shrub species and litter categories. Most litter fell during the summer months, with individual species peaks reflecting particular phenologies. Significant amounts of live aboveground biomass were shed as litter. Amounts of litter from the six species ranged from 7 to 83% of their respective live aboveground biomass. (Authors) *Keywords:* climate*, annual plants*, perennial plants*, ecology/ecosystem*

699 TAGAMI, T., and P. HAYDEN. 1963. An albinistic pocket mouse from Nevada. Journal of Mammalogy 44:415.

A female pocket mouse, *Perognathus formosus*, trapped in Rock Valley, Nevada Test Site had white pelage except for a few black-tipped spines over the rump and scattered black hairs on the head. Eyes were black. The authors estimated that this pelage anomaly occurred with a frequency of less than 1 in 3,500. (TPO) *Keywords:* mammal*, life history*

700 TANNER, V.M. 1963. A new species of *Craniotus* (Coleoptera: Tenebrionidae). Great Basin Naturalist Memoirs 23:167-170.

A new species of beetle was described from material collected on the Nevada Test Site. *Craniotus blaisdelli* was taken 12.5 miles NNE of Mercury, NV in *Larrea-Franseria*; 9.3 miles west of Mercury in *Larrea-Franseria*; 32.5 miles north of Mercury in *Coleogyne* associations. (TPO) *Keywords:* vegetation*, invertebrate*, taxonomy*

701 TANNER, V.M. 1966. Rhynchophora beetles of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 8(2), 35 pp.

As part of the ecological studies of the Nevada Test Site, collections of rhynchophora beetles were made of 310 specimens including 28 genera and 44 species. Morphological characteristics were listed but very little life history was obtained. The plant relationships, number of specimens collected, month and year of collection, and plant hosts or plant communities are given. (BBM) *Keywords:* vegetation*, invertebrate*, life history*, ecology/ecosystem*, taxonomy*

702 TANNER, V.M., and W.A. PACKHAM. 1962. *Pelecyphorus semilaevis* (Horn) (Coleoptera: Tenebrionidae). Great Basin Naturalist Memoirs 22:110-113.

Many specimens of the ground-dwelling beetle, *Pelecyphorus semilaevis* (Horn) were collected near Mercury, Nevada Test Site. Representatives of this species have not been reported on since 1870, and the current authors were able to correctly assign the species to the genus *Pelecyphorus* rather than *Trichiasida* as previously reported by Casey. (TPO) *Keywords:* invertebrate*, taxonomy*

703 TANNER, V.M., and W.A. PACKHAM. 1965. Tenebrionidae beetles of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 6(1), 44 pp.

The intent of this study conducted over a period of three years was to (1) provide descriptions of the species of tenebrionids found at the Nevada Test Site, (2) determine their relative abundance, (3) determine their seasonal activity, and (4) ascertain their plant community relationships. A total of 14,650 beetles representing 46 kinds of tenebrionids was collected with sunken can traps, by hand, and ultra-violet light. Collections were made at regular intervals in the following plant communities: *Larrea-Franseria, Lycium, AtripLex-Kochia, Grayia-Lycium* (disturbed and undisturbed areas), *Salsola, Coleogyne*, Pinyon-Juniper, and Mixed. The data obtained from this study indicate that (1) more species were present in some plant communities than in others; (2) in nuclear disturbed areas a larger number of species was present than in undisturbed areas; (3) some species were more closely associated with some plant associations than with others; (4) those species that were not widely distributed ecologically were fewer in number of individuals, whereas those that were widespread occurred in larger numbers, relatively speaking; (5) the species demonstrated variation in seasonal activity in that some were active for short periods whereas others were active during the whole year; and (6) the two seasonal peaks in population are indicative that some species over-winter as adults whereas others over-winter as larvae. (Authors) *Keywords:* perturbations*, vegetation*, invasive species*, annual plants*, perennial plants*, invertebrate*, ecology/ecosystem*, life history*, taxonomy*

704 TANNER, V.M., and W.W. TANNER. 1974. Additional records of Coleoptera collected at the Nevada Test Site, Mercury, Nevada. Great Basin Naturalist Memoirs 34:218-220.

Thirty-nine species of Coleoptera not previously reported for the Nevada Test Site are listed. *Keywords:* invertebrate*, taxonomy*

705 TANNER, W.W. 1969. New records and distributional notes for reptiles of the Nevada Test Site. Great Basin Naturalist Memoirs 29:31-34.

In a previous publication, Reptiles of the Nevada Test Site, the author listed 28 species of reptiles. Since then, three additional species have been added and increased understanding of other species has been noted. Discussion is given for 9 taxa including distribution of the species. (BBM) *Keywords:* reptile*, ecology/ecosystem*, taxonomy

706 TANNER, W.W. 1982. Herpetological notes from the Nevada Test Site. Great Basin Naturalist Memoirs 42(2):219-222.

During the years 1965-1971, considerable data were gathered that included information concerning species not previously reported. These included *Chionactis occipatalis talpina, Coleonyx variegatus utahensis, Crotaphytus collaris bicinctores, Cnemidophorus tigris tigris,* and *Sauromalus obesus obesus*. Although complete information concerning their life histories is not reported, some information concerning growth and reproduction is included. (Authors) *Keywords:* reptile*, life history*, taxonomy*

707 **TANNER, W.W., and B.H. BANTA. 1962. The distribution of *Tantilla utahensis* Blanchard. Great Basin Naturalist Memoirs 22:116-118.**

Documents the presence of *Tantilla utahensis* in southern Nevada from the western edge of Yucca Flat, NTS. As *T. utahensis* was previously found only in Utah and east-central California, these records eliminate the hiatus in distribution. (TPO) *Keywords:* reptile*, taxonomy

708 **TANNER, W.W., and B.H. BANTA. 1977. The Systematics of *Crotaphytus wislizeni*, The Leopard Lizards. Part III. The Leopard Lizards of the Great Basin and Adjoining Areas, with a Description of a New Subspecies from the Lahontan Basin. Great Basin Naturalist Memoirs 37:225-240.**

A general analysis of the populations of *Crotaphytus wislizeni* in the Great Basin in presented. A new subspecies, *C. Wislizeni maculosus*, for the Lahontan Basin, Nevada, is described and comparisons of color pattern, some scale patterns, and skull measurements are presented. (CAW) *Keywords:* reptile*, ecology/ecosystem*, taxonomy*

709 **TANNER, W.W., and J.M. HOPKIN. 1972. Ecology of *Sceloporus occidentalis longipes* Baird and *Uta stansburiana stansburiana* Baird and Girard on Rainier Mesa, Nevada Test Site, Nye County, Nevada. Brigham Young University Science Bulletin, Biological Series 15(4), 39 pp.**

This paper constitutes the first in a series of terminal reports to the United States Atomic Energy Commission for contract AT (11-1) 1496. It includes a major study on the ecology of the western fence lizard, *Sceloprorus occidentalis longipes*, on Rainier Mesa. Also presented is a comparative study of three populations of *Uta stansburiana stansburiana* Baird and Girard, with special emphasis given to the Uta population on Rainier Mesa. Extensive data for the *S. o. longipes* study were gathered during periods of lizard activity in the years 1965 through 1968; limited observations and samplings continued through 1971. The study plot covered an area of 6.2 acres in a pinyon-juniper community situated at 7,480 ft elevation. Studies include descriptions of the physical environment, biotic environment, behavior, parasites, temperature requirements, reproduction, food habits and home range. A maximum estimate for the home range size of 95 percent of the adult male lizards of this population is given as 1.67 acres. It was noted that nearly all individuals consistently remained in a given area for three or more years without changing their center of activity. Those few who did effect a change appeared to do so early in the spring before advent of the mating period. *S. o. longipes* does not move about foraging for food, but ingests, apparently with little discrimination, any suitablysized prey discernible in its immediate vinicity. Utilization of available arthropods (particularly ants) is of considerable importance in the lizard's ability to survive in high altitudes. *S. o. longipes* basks, increasing its rate of metabolism to permit extension of its feeding periods. This extension promotes an earlier laying of eggs to insure reproduction. Conclusions derived from the comparative study of *Uta stansburiana* are that: (1) *Uta* live longer at high altitudes and population structure is different from that at lower elevations, (2) *Uta* from higher elevations attain a larger size, and (3) with a larger average size for adults in higher elevations, there are more eggs per clutch. (BBM) (LE) *Keywords:* reptile*, invertebrate*, ecology/ecosystem*, life history*, nutrition/diet*

710 **TANNER, W.W., and C.D. JORGENSEN. 1963. Reptiles of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series 3(3), 31 pp.**

Ecological studies have been conducted at the Nevada Test Site to determine how animal populations are affected by nuclear weapons. In the present study twenty-nine species of reptiles have been taken including one tortoise, thirteen lizards, and fifteen snakes. Data presented includes a description and, where feasible, a discussion of the geographic and ecological distribution, external morphology as related to taxonomic identification, systematic position of each subspecies, and seasonal occurrence. The biology of some species, especially *Uta s. stansburiana* and *Cnemidophorus t. tigris*, is summarized for seasonal fluctations, population densities, survival, and growth rate. Vegetation was analyzed in all cases where detailed vegetation analysis was considered important. (BBM) *Keywords:* desert tortoise*, vegetation*, reptile*, ecology/ecosystem*, life history*, taxonomy*

711 **TANNER, W.W., and J.E. KROGH. 1973. Ecology of *Phrynosoma platyrhinos* at the Nevada Test Site, Nye County, Nevada. Herpetologica 29:327-342.**

The natural history of *Phrynosoma platyrhinos p.* was studied in populations at the Nevada Test Site, Mercury, Nevada

(USA). Individuals were marked and kept under surveillance from 1965 through 1971. Reproductive cycles were examined by field observations and autopsy. Hatchlings appear in July and Aug. Growth is rapid for the 1st year and sexual maturity is reached before the 2nd hibernation or soon after emergence from it. Territoriality is limited to broad general areas and is not a pronounced behaviorism as in most sceloporines. Food consists of arthropods, with ants the predominant item. Twenty-four females were producing 160 eggs with a range and average of 3-9 (6.66) eggs. Density was approximately 5/ha with the greatest activity occurring during spring and early summer months. (Authors) *Keywords:* reptile*, ecology/ecosystem*, life history*, nutrition/diet*

712 **TANNER, W.W., and J.E. KROGH. 1973. Ecology of *Sceloporus magister* at the Nevada Test Site, Nye County, Nevada. Great Basin Naturalist Memoirs 33:133-146.**

The natural history of *Sceloporus magister* was studied in populations at the Nevada Test Site, Mercury (USA). Individuals were marked and kept under surveillance from 1965 through 1970. Reproductive cycles were examined by field observation and by autopsy. Hatchlings appear in the population in July and August. Growth is rapid for the 1st year. Sexual maturity is reached before the 2nd hibernation or soon after emergence from it. Territoriality is a pronounced behaviorism; individuals have been observed to remain in a small area for several years. Food consists of arthropods, with ants the predominant item. Reproduction occurs during May and/or June with only 1 clutch/yr. Density is variable and depends on the appropriateness of the habitat. (Authors) *Keywords:* reptile*, ecology/ecosystem*, life history*, nutrition/diet*

713 **TANNER, W.W., and J.E. KROGH. 1974. Ecology of the leopard lizard, *Crotaphytus wislizeni* at the Nevada Test Site, Nye County, Nevada. Herpetologica 30:63-72.**

The natural history of the leopard lizard *C. wislizenii* was studied at the Nevada Test Site, Mercury, Nevada (USA). Individuals were marked and examined from June 1956 through Sept. 1971. Reproduction cycles were examined by field observations and by autopsy. Sexual maturity is reached at or soon after emergence from the 2nd hibernation. Growth is rapid while they are hatchlings and juveniles. Data indicate some territoriality at least for a few years in some individuals. Territories are large and widely dispersed. Food consists of arthropods, lizards and vegetation (mainly blossoms and berries). One clutch of eggs is laid, usually in June, with greater reproductive activity occurring in some years. Density is approximately 5/ha at the study plot in Frenchman Flat. (Authors) *Keywords:* vegetation*, invertebrate*, reptile*, nutrition/diet*, ecology/ecosystem*, life history*

714 **TANNER, W.W., and J.E. KROGH. 1974. Variations in activity as seen in four sympatric lizard species of southern Nevada. Herpetologica 30:303-308.**

Records were kept on the number of individuals observed and captured /h of each day over 2 summers at the Nevada Test Site (USA). The 4 spp. of lizards studied were *Callisaurus draconoides, Cnemidophorus tigris, Crotaphytus wislizenii* and *Phrynosoma ptatyrhinos*. On an hourly basis *Callisaurus* was always the more abundant species ranging from 67-100% of the total of all species observed. *Cnemidophorus* was usually the 2nd most abundant species followed by *Crotaphytus* and *Phrynosoma* in that order. The same trend was observed on a seasonal basis. *Callisaurus* and *Cnemidophorus* escape capture best at the time of day when they were most abundant. (Authors) *Keywords:* reptile*, ecology/ecosystem*

715 **TANNER, W.W., and J.E. KROGH. 1975. Ecology of the zebra-tailed lizard, *Callisaurus draconoides*, at the Nevada Test Site. Herpetologica 31(3):302-16.**

The biology of the Zebra-tailed lizard, *Callisaurus draconoides* was studied at the Nevada Test Site, Mercury, Nevada. Individuals were marked from June 1965 through September 1971. Reproductive cycles were examined by autopsy and field observation. All individuals are sexually mature after the second hibernation. Growth is rapid during the hatchling and juvenile age groups, but slows after they are 2 years old. Territories are moderately large and are maintained by juveniles and adults. Food consists of arthropods. One clutch of three to six eggs is laid usually in June or early July. The reproductive cycles are renewed in August or September with males preceding females by a few weeks. Density may vary from year to year with a range 12-15 individuals/hectare at the Frenchman Flat study plot. (Authors) *Keywords:* invertebrate*, reptile*, ecology/ecosystem*, life history*, nutrition/diet*

716 **TAUB, D.R., J.R. SEEMANN, and J.S. COLEMAN. 2000. Growth in elevated CO_2 protects photosynthesis against high**

temperature damage. Plant Cell and Environment 23:649-656.

We present evidence that plant growth at elevated atmospheric CO_2 increases the high-temperature tolerance of photosynthesis in a wide variety of plant species under both greenhouse and field conditions. We grew plants at ambient CO_2 (~ 360 μmol mol^{-1}) and elevated CO_2 (550-1000 μmol mol^{-1}) in three separate growth facilities, including the Nevada Desert Free-Air Carbon Dioxide Enrichment (FACE) facility. Excised leaves from both the ambient and elevated CO_2 treatments were exposed to temperatures ranging from 28 to 48°C. In more than half the species examined (4 of 7, 3 of 5, and 3 of 5 species in the three facilities), leaves from elevated CO_2-grown plants maintained PSII efficiency (F_v/F_m) to significantly higher temperatures than ambient-grown leaves. This enhanced PSII thermotolerance was found in both woody and herbaceous species and in both monocots and dicots. Detailed experiments conducted with *Cucumis sativus* showed that the greater F_v/F_m in elevated versus ambient CO_2-grown leaves following heat stress was due to both a higher F_m and a lower F_o, and that F_v/F_m differences between elevated and ambient CO_2-grown leaves persisted for at least 20 h following heat shock. *Cucumis sativus* leaves from elevated CO_2-grown plants had a critical temperature for the rapid rise in F_o that averaged 2.9°C higher than leaves from ambient CO_2-grown plants, and maintained a higher maximal rate of net CO_2 assimilation following heat shock. Given that photosynthesis is considered to be the physiological process most sensitive to high-temperature damage and that rising atmospheric CO_2 content will drive temperature increases in many already stressful environments, this CO_2-induced increase in plant high-temperature tolerance may have a substantial impact on both the productivity and distribution of many plant species in the 21st century. (Authors) *Keywords:* FACE*, perturbations*, annual plants*, physiology*

717 **TAYLOR, W.D., and K.R. GILES. 1979. Freshwater Algae of the Nevada Test Site. EPA EMSL-LV-0539-25. U.S. Environmental Protection Agency, Las Vegas, NV, 29 pp.**

Fifty-two species of freshwater algae were identified in samples collected from the eight known natural springs of the Nevada Test Site. Although several species were widespread, 29 species were site specific. Diatoms provided the greatest variety of species at each spring. Three-fifths of all algal species encountered were diatoms. Well-developed mats of filamentous green algae (Chlorophyta) were common in many of the water tanks associated with the springs and accounted for most of the algal biomass. Major nutrients were adequate, if not abundant, in most spring waters--growth being limited primarily by light and physical habitat. There was some evidence of cesium-137 bioconcentration by algae at several of the springs. (Authors) *Keywords:* EPA*, hydrology*, wetlands*, microbiota*, ecology/ecosystem*, radiation*, taxonomy*

718 **THEODORAKIS, C.W., J.W. BICKHAM, T. LAMB, P.A. MEDICA, and T.B. LYNE. 2001. Integration of Genotoxicity and Population Genetic Analyses in Kangaroo Rats (*Dipodomys merriami*) Exposed to Radionuclide Contamination at the Nevada Test Site, USA. Environmental Toxicology and Chemistry, Vol. 20, No. 2, pp. 317-326.**

We examined effects of radionuclide exposure at two atomic blast sites on kangaroo rats (*Dipodomys merriami*) at the Nevada Test Site, Nevada, USA, using genotoxicity and population genetic analyses. We assessed chromosome damage by micronucleus and flow cytometric assays and genetic variation by randomly amplified polymorphic DNA (RAPD) and mitochondria) DNA (mtDNA) analyses. The RAPD analysis showed no population structure, but mtDNA exhibited differentiation among and within populations. Genotoxicity effects were not observed when all individuals were analyzed. However, individuals with mtDNA haplotypes unique to the contaminated sites had greater chromosomal damage than contaminated-site individuals with haplotypes shared with reference sites. When interpopulation comparisons used individuals with unique haplotypes, one contaminated site had greater levels of chromosome damage than one or both of the reference sites. We hypothesize that shared-haplotype individuals are potential migrants and that unique-haplotype individuals are potential long-term residents. A parsimony approach was used to estimate the minimum number of migration events necessary to explain the haplotype distributions on a phylogenetic tree. The observed predominance of migration events into the contaminated sites supported our migration hypothesis. We conclude the atomic blast sites are ecological sinks and that immigration masks the genotoxic effects of radiation on the resident populations. (Authors) *Keywords:* mammal*, physiology*, radiation*

719 **TOWNER, J.W. 1965. The effect of radioactive fallout at the Nevada Test Site on the chromosomes of the pocket mouse. In: (Hungate, F.P., Ed.) *Radiation and Terrestrial Ecosystems*, Health Physics 11:15691571.**

Native populations of the long-tailed pocket mouse, *Perognathus formosus* were trapped at the Nevada Test Site from an area with a history of heavy contamination by radioactive fallout, but uncontaminated for 3 yr previous to trapping; and from an unexposed control area. With one possible exception, no unequivocal evidence has been obtained for the presence of a persistent, inherited chromosome aberration in either population. (Author) *Keywords:* mammal*, physiology*, radiation*

720 **TOWNER, J.W., and R.G. LINDBERG. 1966. Persistent radiation induced chromosomal changes in native pocket mouse populations of the Nevada Test Site. USAEC Report SAN-510-2, 81 pp.**

A study was made of the persistence of chromosome damage in wild populations of the long-tailed pocket mouse, *Perognathus formosus* at the Nevada Test Site (NTS). Animals were collected in 1963 and 1964 from the previously contaminated hills east of the old Ground Zeros at Yucca Flat (YF) and from an essentially uncontaminated area north of Jackass Flats (JF). The infinite environmental dose to the YF study area was about 200 R from weapons tests between 1951 and 1958 and perhaps as much as 4,000-6,000 R total cumulative gamma dose from Project Sedan in 1962. The karyotype (2n = 36) consisted of 8 pairs of large metacentrics, 1 pair of small metacentrics, 8 pairs of small acrocentrics and the two sex chromosomes. Chromosomes 5, 6, 7, 8, 10, 18, X, and Y and three groups of autosomes were identifiable. Somatic chromosomes were generally studied in two tissues, mostly uncultured marrow and cultured kidney cells. Analyses were made under the microscope or from karyotypes. Meiosis was also examined in some males. No inherited aberrations were detected in the sex chromosomes, the acrocentrics, or the metacentrics Nos. 5, 6, 7 or 10. No inherited numerical aberrations were found. No animal had unequivocal cytogenetic or somatic symptoms of radiation exposure. One of the most important findings was that two animals from the contaminated area (2.4%) and one from the control area (2.2%) had a consistent, presumably inherited, karyotype aberration. All 3 cases seemed to involve nonreciprocal gain or loss of chromatin from the short arm of a metacentric autosome. All 3 animals were phenotypically normal and survived for a year or more in captivity. It was concluded that inherited chromosome aberrations were no more frequent in pocket mice from an area at Yucca Flat that had been chronically contaminated by radioactive fallout than in animals from the essentially unexposed habitat at Jackass Flats. (Authors) (FMM) *Keywords:* mammal*, physiology*, radiation*

721 **TUELLER, P.T., and J.E. CLARK. 1976. Nonradiation Effects on Natural Vegetation From the Almendro Underground Nuclear Detonation. NVO-409-3, Agricultural Experiment Station, Max C. Fleischmann College of Agriculture, University of Nevada, Reno.**

Nonradiation effects on the natural vegetation, primarily pinyon/juniper woodland, in the vicinity of project Almendro have been studied. Almendro was an underground, contained nuclear weapons test conducted at 0600 hours PDT on June 6, 1973. The detonation occurred 3,490 feet below ground surface in drill hole U19v, Area 19 of the Atomic Energy Commission's Nevada Test Site. Evaluation of tree and shrub damage along two radiating transects indicated that numerous trees were damaged or killed. Most of the damage obvious during the summer of detonation occurred from falling rock. Fresh rock movements were noted in flat areas and especially along cliffs. At 10,000 ft from surface zero, damage occurred primarily because of the incidence of cliffs in the plot areas. At 500 ft from surface zero, 38 percent of the pinyon trees and 29 percent of the juniper trees were found dead after detonation based on data from a single one-fifth acre plot. However of the other nine stations that were studied by aerial photography, there was no pinyon nor juniper mortality found at six of them although each station was farther from surface zero. (Authors) *Keywords:* geology*, perturbations*, perennial plants*

722 **TUELLER, P.T., A.D. BRUNER, R. EVERETT, and J.B. DAVIS. 1974. The ecology of Hot Creek Valley, Nevada and nonradiation effects of an underground nuclear detonation. NVO-409-2, 55 pp.**

Vegetation on approximately 70 square miles of the north portion of Hot Creek Valley were mapped using aerial photographs in conjunction with data from 108 ground macroplots. Soils and vegetation were described at each plot. Remote sensing data suggested that the vegetation was not subjected to any harmful physiological effect from ground shock from Faultless (UC1). Areas have been disturbed by AEC contractors and recommendations for revegetating them are included. (TPO) *Keywords:* soil property*, perturbations*, vegetation*, ecology/ecosystem*, revegetation*

723 **TUELLER, P.T., R.J. TAUSCH, and V. BOSTICK. 1991. Species and Plant Community Distribution in a Mojave-Great Basin Desert Transition. Vegetation 92:133-150.**

Multivariate analyses were used to describe the vegetation characteristics of a transition from low-elevation Mojave desert to higher-elevation Great Basin desert. Vegetation data used were from Plutonium Valley in the Nevada Test Site. Data from forty nine releves were analyzed with two classifications (two-day indicator analysis or TWINSPAN and unweighted paired group cluster analysis or CLUSTER). Three ordinations, reciprocal averaging (RA), detrended reciprocal averaging

(DCA) and non-metric multidimensional scaling (MNDS), were also used. A rotational correlation analysis was used to determine the vector direction of environmental gradients that correlate best with ordination results. Only token correspondence was found between multivariate classes generated by TWINSPAN and CLUSTER, and seven classes (plant communities) identified from field reconnaissance. The latter seven communities were based on differences in dominant species. Distribution of the vegetation was related more to beta diversity than alpha diversity. Individual species were much less diagnostic than the amount of plant cover, groups or guilds of species or differences in elevation and steepness of slope. Because of the high beta diversity the NMDS ordination gave results with the greatest ease of interpretation. (Authors) *Keywords:* vegetation*, ecology/ecosystem*

724 TURNER, F.B. 1963. Biotic communities of the Nevada Test Site. (A review) Ecology 44:633-634.

This review of "Biotic Communities of the Nevada Test Site" (Allred, C.M., D.E. Beck, and C.D. Jorgensen, 1963, abstract #28) critiques the merits and shortcomings of the first attempt at describing the biota of the Nevada Test Site. After a few caveats, the author states, "Investigators planning ecological research at the Nevada Test Site will find careful study of this bulletin an indispensable prelude to further endeavor." (TPO) *Keywords:* perturbations*, vegetation*, invertebrate*, vertebrate*, ecology/ecosystem*

725 TURNER, F.B. 1963. Influence of a cratering device on close-in populations of lizards. (Project Sedan) USAEC Report PNE-224F, 39 pp.

Prior to the Sedan test on July 6, 1962, the density of adult lizards northeast of the prospective ground zero was estimated on the basis of repeated sampling of selected areas. Samples were taken by hand collecting and by means of buried cans, which served as traps for both lizards and various species of arthropods. Measurements of cumulative gross gamma dosages in the study areas were also made at 2" and 36" above the ground, 2" below the ground, and in the tissues of lizards by means of small implanted glass microdosimeters. In shrubby areas northeast of ground zero, the pre-test density of *Cnemidophorus tigris* in June was estimated at 5 to 10 per acre, the density of *Crotaphytus wislizenii* at 1 to 2 per acre. No juveniles of either species were observed. Densities of *Uta stansburiana* and *Phrynosoma ptatyrhinos* could not be estimated from the data acquired. After the test, during August and again in November, no adult lizards were observed closer to ground zero than 5,500 ft. (Author) *Keywords:* perturbations*, reptile*, invertebrate*, radiation*

726 TURNER, F.B. 1963. Quantitative relationships between fallout radioiodine on native vegetation and in the thyroids of herbivores. Health Physics 9:1241-1246.

Following the Sedan test of July 6, 1962, the time-specific relationships between I-131 on vegetation and in jackrabbit thyroids were measured and compared to predictions derived from a deterministic model. The accord is considered good enough to encourage further application of this approach to environmental problems involving food-chain transfers of radioisotopes. Disparities between predicted and observed levels are reviewed in terms of possible sources of error in estimating input parameters. The value of considering this type of problem probabilistically is emphasized and a stochastic revision of the model is derived. (Author) *Keywords:* vegetation*, mammal*, nutrition/diet*, radiation*, methods*

727 TURNER, F.B. 1965. Uptake of fallout radionuclides by mammals and a stochastic simulation of the process. In: (Klement, A.W., Jr., Ed.) *Radioactive Fallout from Nuclear Weapons Tests*, AEC Symposium Series 5 (CONF-765), pp. 800-820.

A deterministic model, designed to predict time-specific levels of I-131 on vegetation, was revised as a probabilistic simulation of the experience of a consumer in a fallout field. The stochastic model was used to generate synthetic populations of up to 1,000 individuals. The frequency distributions of thyroidal I-131 in 24 of these hypothetical populations were analyzed in terms of the recommended assumptions of the Federal Radiation Council, namely that the majority of individuals in a population does not vary from the average by a factor greater than 3. In only two of the distributions did more than 2% of the population exceed three times the mean. The frequency distributions predicted by the model were all skewed to the high side and approximated lognormal distributions. A number of frequency distributions of radionuclides recorded in the literature were reviewed, and X^2-tests indicated that most of them were not normal. All the non-Gaussian distributions were skewed to the high side, and some of them were apparently lognormal. It is concluded that the general form of the synthetic distributions produced by the model is in agreement with most past observations. It is further suggested that such asymmetrical distributions may be more likely than normal ones. Consideration was also given to the possible relation between the frequency distribution of a radionuclide in diets and the frequency distribution of the substance in the tissues of animals consuming these diets. (Author) *Keywords:* vegetation*, mammal*, nutrition/diet*, radiation*, methods*

728 **TURNER, F.B. 1966. Growth rate of lizards (*Uta stansburiana*) exposed to chronic gamma radiation. In: (Sacher, G.A., Ed.) *Radiation Effects on Natural Populations*, pp. 46-52.**

A population of chronically irradiated *Uta stansburiana* exhibited reduced growth compared to control populations. However, the population density was greater in the irradiated population as well so it was not possible to eliminate a density dependent phenomenon rather than radiation as a causative factor. (TPO) *Keywords:* reptile*, life history*, radiation*

729 **TURNER, F.B. 1968. Life history of a lizard. (A review) Evolution 22:841-842.**

A critique of the book *The Life and Demography of the Sideblotched Lizard, Uta stansburiana* (Tinkle, D.W., 1967, Misc. Publ., Mus. of Zool., Univ. Mich., No. 132, 182 pp.). Judged to be one of the most significant population studies of a lizard in several years. Chapter on demography of *Uta stansburiana* considered the most interesting and important portion of the book by the reviewer. Also demonstrates the enormous field effort required to evaluate demographic problems under natural conditions. (TPO) *Keywords:* reptile*, life history*

730 **TURNER, F.B. (Ed.). 1972. Rock Valley Validation Site Report. US/IBP Desert Biome Res. Memo. 72-2. Utah State University, Logan, 68 pp.**

Various abiotic and biological measurements were made on a 46.1 ha (113.9 acres) validation site in Rock Valley, Nye County, Nevada, during 1971. Abiotic measurements included wind speed and direction, air temperature, insolation, rainfall, soil temperatures, soil moisture contents, and selected physicochemical attributes of soils. Biological measurements included estimates of standing crops of annual and perennial plants, together with state changes associated with production of new tissue during the spring of 1971; periodic estimates of the relative abundances of various ground- and shrub-dwelling arthropods; and estimates of densities and biomasses of selected species of vertebrates. (Author) ((CAW) *Keywords:* IBP*, climate*, soil property*, invasive species*, annual plants*, perennial plants*, invertebrate*, bird*, reptile*, mammal*, ecology/ecosystem*

731 **TURNER, F.B. (Ed.). 1973. Rock Valley Validation Site Report. US/IBP Desert Biome Res. Memo. 73-2. Utah State University, Logan, 211 pp.**

Various abiotic and biological measurements were made on a 46.1 ha (113.9 acres) validation site in Rock Valley, Nye County, Nevada, during 1972. Abiotic measurements included wind speed and direction, air temperature, insolation, rainfall, soil temperatures, soil moisture contents, and selected physicochemical attributes of soils. Biological measurements included estimates of standing crops of annual and perennial plants, together with state changes associated with production of new tissues during the spring of 1971; periodic estimates of the relative abundances of various ground- and shrub- swelling arthropods, and estimates of densities and biomasses of selected species of vertebrates. (Author) (CAW) *Keywords:* IBP*, climate*, soil property*, invasive species*, annual plants*, perennial plants*, invertebrate*, reptile*, bird*, mammal*, ecology/ecosystem*

732 **TURNER, F.B. (Ed). 1975. Rock Valley Validation Site Report 1974 Progress Report. US/IBP Desert Biome Res. Memo. 75-2. Utah State University, Logan, 53 pp.**

During the spring of 1974 the site was estimated to sustain about 40 million annuals (ca. 88/m^2). Over 57% of these plants were two grasses (*Festuca octoflora* and *Bromus rubens*), and these two species, together with *Chaenactis carphoclinia, Chaenactis fremontii, Cryptantha circumscissa,* and *Cryptantha recurvata* made up about 80% of all the annuals on the site. The 1974 density was much higher than densities in 1971 and 1972 (8 and 11/m^2), and not greatly less than that observed in 1973 (ca. 100/m^2). However, the 1974 annuals were extremely small (similar to those of 1972). Production was estimated to range from about 9 to 23 kg/ha, depending upon the zone of reference. The overall site mean was about 17.4 kg/ha. Fruits made up around 19% of the 1974 production. Survival of annuals in 1974 was poor, ranging from around 20% in Zone 24 to 55% in Zone 20 (cf.>90% in 1973). Plants increased in size (and weight) during 1973, and remeasurements of shrubs in 1974 showed conspicuous volume increases of up to 100% in *Ceratoides lanata* and *Grayia spinosa*. The 1974 estimate of total, live, aboveground standing crop on the site is around 1,200 kg/ha (cf. previous estimate of 962 kg/ha).

Root biomass has been estimated to be in the range of 5,500 to 6,000 kg/ha. The largest contributors to live standing crop are *Lycium andersonii* (344 kg/ha) and *Larrea tridentata* (154 kg/ha). On a site-wide basis, production of new aboveground tissue (shoots, leaves, flowers, and fruits) by perennials in 1974 was estimated to be 181 kg/ha (cf. 157 to 183 kg/ha in 1971 and 1972; 573 kg/ha in 1973). New leaves made up the greatest part of production in 1974 (85%), conspicuously more than in 1973 (45%) and somewhat more than in 1971 (76%) and 1972 (63%). Production of flowers and fruits (ca. 4%) was the lowest observed in four years. The greatest decrease in productivity (relative to 1973) was exhibited by *Lycium andersonii* (-91%), but declines of 35-70% were typical. Only *Grayia spinosa* sustained apparent productivity near 1973 levels. The most abundant mammal on the site is *Perognathus longimembris*. The spring density of this species was round 20/ha (59 g/ha dry weight). This much higher than spring densities observed between 1971 and 1973 (5-10/ha), and clearly derived from the large numbers of animals recruited during the summer of 1973. The estimated spring standing stock (10 species) on the site was around 221 g/ha dry weight, again more than that reported at any time between 1971 and 1973. Reproduction by kangaroo rats, ground squirrels, and grasshopper mice was limited in 1974, and apparently nil by pocket mice. Trapping in the summer of 1974 indicated a slight decline in total numbers of rodents, but a somewhat higher aggregate biomass (273 g/ha). The 1974 reproductive failure may be a density-dependent response associated with the large numbers of rodents present on the site at the beginning of the 1974 breeding season. The most abundant reptile is the lizard, *Uta stansburiana*. The observed density of four other species of lizards was about 43/ha (115 g/ha). The total biomass of five principal lizard species increased about 16% in 1974 (relative to 1973), mainly due to increases in numbers of *Uta stansburiana* and *Cnemidophorus tigris*. (Authors) (EC) *Keywords:* IBP*, climate*, soil property*, invasive species*, annual plants*, perennial plants*, invertebrate*, reptile*, mammal*,ecology/ecosystem*

733 TURNER, F.B. (Ed.). 1976. Rock Valley Validation Site Report. US/IBP Desert Biome Res. Memo. 76-2. Utah State University, Logan, 35 pp.

Abiotic and biological measurements were made on a 46.1-ha site in Rock Valley, Nye County, Nevada, during 1975. Abiotic measurements included wind speed and direction, air temperatures, insolation, rainfall, humidity, soil temperatures and soil moisture tensions. Biological measurements included estimates of standing crops of annual and perennial plants, together with state changes associated with production of new tissue during the spring of 1975; estimates of litter production by six species of shrubs; periodic estimates of the relative abundances of shrub-dwelling arthropods; and estimates of densities and biomasses of selected rodent species. (Author) (CAW) *Keywords:* IBP*, climate*, soil property*, invasive species*, annual plants*, perennial plants*, invertebrate*, bird*, reptile*, mammal*, ecology/ecosystem*

734 TURNER, F.B. (Ed). 1979. Rock Valley Validation Site Report. Final Progress Report. US/IBP Desert Biome Res. Memo. 77-2. Utah State University, Logan, 42 pp.

Abiotic and biological measurements were made on a 46.1 ha site in Rock Valley, Nye County, Nevada, during 1976. Abiotic measurements included wind speed and direction, air temperatures, rainfall, soil temperatures, and soil moisture tensions. Biological measurements included estimates of standing crops of annual and perennial plants, together with state changes associated with production of new tissue during the spring and fall of 1976; estimates of litter production by six species of shrubs; and removal trapping of ground-dwelling anthropods. The Rock Valley site has been divided into six homogeneous zones of vegetation, ranging in extent from 1.41 to 21.21 ha. The vegetation of these zones differs in species composition and relative abundance of major perennials. In all zones, eight shrubs compose from 94-97% of the perennial populations: *Ambrosia dumosa, Ephedra nevadensis, Ceratoides lanata, Grayia spinosa, Krameria parvifolia, Larrea tridentata, Lycium andersonii,* and *L. pallidum. Ambrosia dumosa* is the most common species in all zones. During the spring of 1976 the site was estimated to sustain about 208 million annuals (ca. 451/m^2). This density far exceeded anything observed during the previous five years (cf. 100/m^2 in 1973 and 136/m^2 in 1975). The 1976 flora was also the most diverse observed (more than 59 different species) and contrasts strikingly with the 1975 flora-of which *Festuca octoflora* composed about 76%. In 1975, *Festuca* and five other kinds of annuals made up 92% of the annual population. In 1976, *Festuca, Bromus rubens, Caulanthus lasiophyllus, Chorizanthe rigida,* and various species of *Pectocarya* made up only 55% of the annuals estimated to be present on the site. Annual plants in 1976 were smaller than those of 1975. Production in 1976 was estimated to range from 110 to 158 kg/ha, depending upon the zone of reference. The overall site mean was 146 kg/ha, higher than most previous years, but still far less than that for 1973 (674 kg/ha). *Chorizanthe rigida, Chaenactis carphoclinia, C. fremontii,* and *Bromus rubens* accounted for about 59% of the estimated production by annuals. Fruits made up about 27% of all production, a proportion exceeded only by that observed in 1973 (30%). Leaves (22%), stems

(24%), and flowers (19%) all were produced in about the same amounts. Total coverage by 21 perennial species is about 22% on a sitewide basis. Over 40,000 perennials occur on the site (ca. 9800/ha), and around 10% of these are dead. Overall, the ratio of aboveground standing dead to living plant material has been estimated at 5:4. The 1975 estimate of total live aboveground standing crop on the side was around 100 kg/ha. Root biomass has been estimated to be in the range of 5,500 to 6,000 kg/ha. The largest contributors to live standing crop are *Lycium andersonii* (344 kg/ha) and *Larrea tridentata* (154 kg/ha). On a sitewide basis, production of new aboveground tissues (shoots, leaves, flowers, and fruits) by six species of shrubs of 1976 was estimated to be 330 kg/ha. This is roughly twice that observed in 1971, 1972, 1974, and 1975, but less than the 573 kg/ha reported for 1973. The significant component (ca. 27%) of total net production that occurred in fall, 1976, was unusual. Fall production by *Ambrosia* was particularly good, and this was the principal reason that overall production by *Ambrosia* in 1976 (76 kg/ha) exceeded that of other shrubs. Production by *Lycium andersonii* was around 71 kg/ha; by *Krameria parvifolia*, about 61 kg/ha; and by *Lycium pallidum*, 47 kg/ha. In a year in which other shrubs grew well, *Ephedra nevadensis* produced only about 30 kg/ha, and this was all accomplished in the spring. As in all previous years, new leaves made up the greatest part of production in 1976 (62%). Flowers (6%) and fruits (3%) were produced in good quantities. All species showed increased production relative to 1975, with the biggest changes registered by *Ambrosia dumosa* and *Lycium andersonii*. Survival of shrub seedlings was monitored between 1971 and 1976. The largest numbers of seedlings were established in 1971, 1973, and 1974. In general, it is unusual for seedlings of any species to survive for more than a year, and replacement is correspondingly slow. Data for six years pertaining to vertebrates occupying the site were recapitulated in terms of species densities, mean body weights, standing stocks and reproduction. Annual changes in numbers of *Perognathus formosus* were examined in detail using not only data from 1971-76, but also work by N.R. French ad his colleagues and field experiments by R.M. Chew. The effect of winter rainfall on reproduction by this species was indicated by multiple regression analyses, but the complicating influences of other factors were also emphasized. The general response of certain populations of rodents, lizards, and birds to the enormous net primary production of 1973 was discussed, with particular emphasis on reproductivity. (Author) (EC) *Keywords:* IBP*, climate*, soil property*, invasive species*, annual plants*, perennial plants*, invertebrate*, bird*, reptile*, mammal*, ecology/ecosystem*

735 TURNER, F.B., and C.S. GIST. 1965. Influences of a thermonuclear cratering test on close-in populations of lizards. Ecology 46:845-852.

On July 6, 1962, a large thermonuclear device was detonated at the Nevada Test Site (Project Sedan). It was buried 635 ft underground and had a total yield of 10 kt. The explosion ejected about 7.5 million yd^3 of alluvium and produced a crater 320 ft deep and 1,200 ft in diameter. As part of an investigation of the ecological influences of underground detonations, a study was made of lizard populations within 10,000 ft of ground zero. Adult *Cnemidophorus tigris*, *Crotaphytus wislizenii*, and *Uta stansburiana* were exterminated within 4,000 ft from ground zero. Very few adult lizards of any species were observed within 6,000 ft. No changes attributable to the test were detected at 8,500 to 9,000 ft. Eggs of the three species hatched following the test in areas where adults did not survive. Young *Uta stansburiana* were numerous in August from 2,600 to 9,000 ft from ground zero. By October, the young lizards at 2,600 ft were gone, and mortality at 3,800 ft was extremely heavy. At 9,000 ft the apparent density of young *Uta* was only slightly reduced as compared to that in August. In June, 1963, adults of the three species were observed between 4,500 and 5,000 ft from ground zero, and *Uta* was apparently most abundant. It is possible that *Cnemidophorus* was more sensitive than *Uta* to the deleterious influences. The immediate mortality within 4,000 ft is attributed to the gross physical effects of the detonation (dirt fall and blast) which destroyed all of the vegetation out to 2,000 ft and caused partial damage to 5,000 ft. Delayed mortality, as that exhibited by juveniles which hatched after the test, is attributed to destruction of habitat. Neither the depletion of food resources nor the residual radiation is likely to have been lethal. Absorbed tissue doses, as registered by three microdosimeters implanted in lizards before the test and recovered July 28, were probably significantly less than the free-air dose registered in the same area. (BBB) *Keywords:* perturbations*, reptile*, ecology/ecosystem*, radiation*

736 TURNER, F.B., and R.I. JENNRICH. 1967. The concentration of ^{131}I in the thyroids of herbivores and a theoretical consideration of the expected frequency distribution of thyroidal ^{131}I in a large consumer population. In: Aberg, B., and F.P. Hungate (Eds.) *Radioecological Concentration Processes,* Proceedings of the International Symposium, Stockholm, April 1966 (CONF-660405), pp. 175-182.

A probabilistic version of a mathematical simulation model was used to generate frequency distributions of the amount of I-131 at varying times in the thyroids of individuals making up artificial "populations" of consumers. Positive skewness of output distributions arose not only because of positively skewed distributions of I-131 per gram of food, but also because of multiplicative combinations of random errors. If true, the expected frequency distribution would be lognormal, or at least positively skewed rather than normal. Earlier field data were reexamined in light of the results of the simulation modeling. The data suggested that within 25 miles of the Sedan detonation, the asymmetrical distribution of I-131 on plants was largely responsible for determining thyroidal I-131 in herbivores, but at greater distances multiplicative interaction of variables may have been more important. (TPO) *Keywords:* vegetation*, mammal*, nutrition/diet*, radiation*, methods*

737 TURNER, F.B., and J.R. LANNOM, Jr. 1968. Radiation doses sustained by lizards in a continuously irradiated natural enclosure. Ecology 49:548551.

Desert lizards occupying a 20-acre experimental facility continuously exposed to gamma radiation sustained tissue doses that were less than the cumulative free-air dose. Vegetation and terrain afforded some shielding, but time spent below ground was the major source of protection. It was estimated that, in the course of a year, tissue doses sustained by *Uta stansburiana* were from 0.3 to 0.6 of the cumulative free-air dose, and that about 1/3 of the total dose was experienced between June and August. *Cnemidophorus tigris* spent less time above ground, and sustained annual doses representing only about 0.1 to 0.2 of total incident radiation. The dose experience of *Crotaphytus wislizenii* was intermediate to the other two species. Dose regimes experienced by *Uta stansburiana* in the experimental area are not acutely lethal. (Authors) *Keywords:* reptile*, radiation*

738 TURNER, F.B., and W.E. MARTIN. 1964. Food-chain relationships of Iodine131 in Nevada following the Sedan test of July 1962. USAEC Report PNE236F, 60 pp.

Following the Sedan test of July 6, 1962, in Nevada, the applicability of mathematical models to food-chain transfers of iodine131 in natural environments was examined. The amounts of radioiodine measured in the thyroids of jackrabbits collected at 5-day intervals between July 5 and August 5 were compared to levels predicted by models on the basis of estimated levels of radioiodine on vegetation as of July 6. Four areas, from 20 to 110 miles from ground zero, were studied between 5 and 30 days after the test. The basic model was deterministic, but a probabilistic model predicated on the same assumptions was also developed and tested. The performance of the models was good enough to encourage further work of this nature. Analyses of vegetation samples suggest that the distribution of radioiodine on vegetation after the test was lognormal, not normal. When distributions of radioiodine on vegetation are defined as lognormal, and frequency distributions of thyroid radioiodine in large synthetic populations are generated by the computer, these distributions are also lognormal. Whether such distributions reflect the situation in nature depends on the validity of the assumptions built into the model. We believe that the model assumptions are qualitatively sound, and that lognormal distributions of radioisotope concentrations in organs are probably characteristic of populations consuming vegetation contaminated by local fallout. This conclusion is supported both by measurements of radioiodine on vegetation at various times between July 11 and August 5, and by analyses of observed distributions of radioiodine in the thyroid of herbivores consuming this vegetation. The assumption of the Federal Radiation Council that the majority of individuals do not vary from the average by a factor greater than three, appears reasonable, both on the basis of actual observations and analyses of synthetic distributions of 1,000 individuals. If measurements of radioiodine on sagebrush (*Artemisia tridentata*) in the vicinity of Currant, Nevada (110 miles from ground zero) were even close to levels of radioiodine on cattle forage (i.e., no more than 10 times higher), it is an unavoidable conclusion that had milk been produced in this area during July of 1962, it would have contained radioiodine (2,000-3,000 uuc/1) temporarily far in excess of the limit of Range II recommended by the Federal Radiation Council (100 uuc/1). Levels would have been higher in areas closer to ground zero. Fortunately, there is little dairying in this part of Nevada. (Authors) *Keywords:* vegetation*, perennial plants*, mammal*, nutrition/diet*, radiation*, methods*

739 TURNER, F.B, and J.F. MCBRAYER (Eds.). 1974. Rock Valley Validation Site Report. US/IBP Desert Biome Res. Memo. 74-2. Utah State University, Logan, 64 pp.

Various abiotic and biological measurements were made on a 46.1 ha (113.9 acres) site in Rock Valley, Nye County, Nevada, during 1973. Abiotic measurements included wind speed and direction, air temperatures, insolation, rainfall, soil temperatures, and soil moisture contents. Biological measurements included estimates of standing crops of annual and perennial plants, together with state changes associated with production of new tissue during the spring of 1973; periodic estimates of the relative abundances of various ground- and shrub-dwelling arthropods; and estimates of densities and biomasses of selected species of vertebrates. (Authors) (CAW) *Keywords:* IBP*, climate*, soil property*, annual plants*, perennial plants*, invertebrate*, bird*, reptile*, mammal*, ecology/ecosystem*

740 TURNER, F.B., and P.A. MEDICA. 1977. Sterility Among Female Lizards (*Uta stansburiana*) Exposed to Continuous

Gamma Irradiation. Radiation Research 70:154-163.

A natural population of the lizard *Uta stansburiana* occupying a fenced 9-ha area in southern Nevada was exposed to essentially continuous γ irradiation from an artificial source between February 1964 and September 1973. Tissue doses were estimated using implanted lithium fluoride microdosimeters. Females became sterile as early as 11 months of age, but many were still fertile at ages of 20 months and a very few may have reproduced at 32 months. Dosimetry showed some females to be sterile after accumulated doses of around 500 rad, while others may have required 1,000 or more rad. One female estimated to have received over 1,200 rad was still reproductive. Irradiated females may pane through a state of half sterility, during which time they possess one functional ovary. Female *U. stansburiana* are sterilized at lower doses than the sterilizing dose (1500 rad) previously suggested for the leopard lizard, *Crotaphytus wislizenii*. (Authors) *Keywords:* reptile*, life history*, radiation*

741 TURNER, F.B., and D.C. RANDALL. 1987. The phenology of desert shrubs in southern Nevada. Journal of Arid Environments 13:119-128.

Phenological observations between 1958 and 1976 of seven kinds of shrubs to southern Nevada are reviewed, and mean dates of first leafing, flowering and fruiting calculated. Flowering dates of different species were variable but fruiting of all species generally followed flowering dates by about 2 weeks. Multiple regression models predicting dates of first leafing and flowering were derived based on rainfall and mean monthly air temperatures. Flowering models explained appreciably more of observed year-to-year variability than leafing models. The models were not sensitive to short periods of unusually low temperatures and could not predict occasional failures of species to produce flowers. (Authors) *Keywords:* climate*, perennial plants*, life history*, methods*

742 TURNER, F.B., and D.C. RANDALL. 1989. Net Production by Shrubs and Winter Annuals in Southern Nevada. Journal of Arid Environments. 17:23-26.

The annual flora of Rock Valley in southern Nevada is composed of about 60 species of winter annuals. Estimates of net aboveground production (ANP) by these plants ranged from <0.1 g/m^2 (1965) to 64 g/m^2 (1973). ANP by perennials (principally nine species of shrubs) ranged from 20 g/m^2 to 68 g/m^2 between 1966 and 1976. Germination and growth of annuals are controlled by rains occurring between late September and January. Growth of perennials is similarly affected, but spring and summer rains are also influential. Rainfall-production models accommodating the idea of a minimal amount of precipitation necessary to promote new growth, estimated rainfall thresholds of 26 mm for annuals and 21 mm for perennials. (Authors) *Keywords:* climate*, perennial plants*, annual plants*, ecology/ecosystem*, life history*

743 TURNER, F.B., and A.T. VOLLMER. 1980. Ecological Effects of Precipitator Ash on Desert Plants. Annual Report to Southern California Edison Research and Development Series 80-RD-106.

In 1979 the general pattern manifested in 1978 persisted: numbers of species observed declined in plots treated with ash, and were highest in untreated plots. Densities in plots receiving 30 and 100 mt/ha of ash have been conspicuously reduced to only 3-4% of that in controls. Rates of germination generally declined with increasing amounts of ash in soil. Germination was partially sustained in soil-ash mixtures of 10 to 20%, but dropped off sharply at mixtures above 50%. (Authors) *Keywords:* perturbations*, vegetation*, ecology/ecosystem*, life history*

744 TURNER, F.B., E.B. EDNEY, and A.T. VOLLMER. 1979. Ecological Effects of Precipitator Ash on Desert Plants and Animals. Annual Report to Southern California Edison, Research and Development Series 74-RD-101.

A field experiment was established in Jackass Flats, Nevada, to test possible effects of precipitator ash from the Mojave Generating Station on native vegetation. Target treatment levels were 10, 30, and 100 metric tons of ash per hectare. No treatment-related effects were observed in the first growing season (1977). During the second season (1978), numbers of annual plants germinated were definitely reduced in plots exposed to 30 and 100 mt/ha of ash. Growth, phenology, and reproduction by shrubs failed to indicate clearcut treatment effects. Egg production by female beetles was unaffected by a

diet amended with 5% ash, but was reduced by 10% and 25% ash diets; testes were unaffected by treatments. (Authors) *Keywords:* perturbations*, perennial plants*, annual plants*, invertebrate*, life history*

745 TURNER, F.B., G.A. HODDENBACH, and J.R. LANNOM, Jr. 1965. Growth of lizards in natural populations exposed to

gamma irradiation. In: (Hungate, F.P., Ed.) *Radiation and Terrestrial Ecosystems*, Health Physics 11:1585-1593.

Growth of the iquanid lizard, *Uta stansburiana* was analyzed in four 20-acre areas in Nevada between July and November 1964. One plot was irradiated continuously during this interval (except for sampling time). Growth of lizards in all areas appeared the same until October and November, when growth in the irradiated plot fell behind that occurring in the control areas. Analyses of variance involving both body lengths and weights showed highly significant differences between areas which are primarily attributable to the retardation of growth in the irradiated plot. The difference between plots is not, at this time, attributed to irradiation. Some alternative interpretations of the situation are discussed. (Authors) *Keywords:* reptile*, life history*, radiation*

746 **TURNER, F.B., R.I. JENNRICH, and J.D. WEINTRAUB. 1969. Home ranges and body size of lizards. Ecology 50:1076-1081.**

The relationship between home range, A (m^2) and body weight, W (g) among adults of 13 spp. of terrestrial lizards was estimated as: $A = 171.4W^{0.95}$. The slope of the logarithmic regression is steeper than that relating standard metabolic rate, M (cm^3O_2/hr) at 30° C and body weight: $M = 0.82W^{0.62}$. These functions are compared with similar regressions relating the home ranges and basal metabolic rates of birds and mammals to body size. Two major difficulties in the interpretation of such data are discussed. (Authors) *Keywords:* reptile*, bird*, mammal*, physiology*, ecology/ecosystem*

747 **TURNER, F.B., P.A. MEDICA, and R.B. BURY. 1987. Age-size Relationships of Desert Tortoises (*Gopherus agassizi*) in Southern Nevada. Copeia 4:974-979.**

We assigned ages of 1-4 yr to 15 desert tortoises originally marked in Rock Valley, Nevada, between 1963 and 1965, at which time their plastron lengths ranged from 47-74 mm. Continued measurements of these tortoises enabled us to estimate mean body sizes of tortoises from 1-26 yr of age. Growth of males and females over this period did not differ significantly. Tortoises grew to plastron lengths of 100 mm in 6-7 yr, to 130 mm in 10-11 yr, to around 150 mm in 13-14 yr and were 215 mm long at estimated ages of 24 yr. Four females 23-24 yr old were X-rayed in 1985; three had clutches of 4-5 eggs. If Rock Valley female tortoises are sexually mature at the same body size as those in eastern San

Bernardino County, California, sexual maturity is attained at an age of 17-20 yr. (Authors) *Keywords:* desert tortoise*, life history*

748 **TURNER, F.B., P.A. MEDICA, and B.W. KOWALESKY. 1976. Energy utilization by a desert lizard, *Uta stansburiana*. US/IBP Desert Biome Monograph; No. 1, 56 pp. Utah State University Press, Logan, UT.**

Energy flow of *Uta stansburiana* in southern Nevada was estimated over a three-year March 1, 1965, and February 29, 1968. Analysis was restricted to energy and did not include energy ingested but not utilized. Energy of (R) and elimination (E), as well as changes in standing stock (ΔB), were estimated for monthly intervals over a three-year span. Production (P) was calculated as $E \pm \Delta B$. The basic analysis was done with a computer program which simulated daily changes in the states of the lizard populations. For each of the three years initial population states were specified in terms of densities and age distributions based on field data. Age-specific mortality rates were assumed to be exponential, but annual survival was based on field measurements. Newborn lizards were added to the populations during the summer in keeping with observations and measurements of clutch size and frequency, and incubation periods of eggs. Numbers of lizards in each sex and age category were calculated by the computer for each day of each year. Weight changes of various sex and age groups were based on measurements of body weight made during the time intervals in question, and the computer simulation calculated mean body weights for all groups on a daily basis. Losses from the populations could be computed from the age-specific death rates and the weight change functions. During any time period, elimination (E) was calculated as the caloric equivalent (1.57 kcal/g live weight) of all *Uta* dying. In the basic computer simulation minimum (night) oxygen consumption was estimated by equations of the form: $cc\ O_2 = XW^YZ^T$, where W =body weight and T = body temperature. Body temperatures were estimated on an hourly basis with a simple model based on hourly measurements of air temperature and insolation. The maximum body temperature attainable (T_{max}), based on field observations, ranged from 32 C in early January to 38 C in mid-July. T_{max} was computed for each day of the year from a sine function. Minimum respiratory rates were increased by factors of 2.0 and 2.5 (depending on body temperatures) to compensate for increased oxygen consumption during daytime activity. Estimated annual energy flow of *Uta stansburiana* ranged from 1831 kcal/ha in 1965-6 to 2794 kcal/ha in 1966-7. Energy of respiration ranged from 1495 to 2259 kcal/ha and production from 336 to 536 kcal/ha. In terms of the ratio of production to respiration (P/R), *Uta* was functionally similar to other ectothermic animals.

Annual variations in P/R ranged from 22 to 34% and seasonal fluctuations of from 0 to 62% were observed. Annual fluctuations in energy parameters were closely tied to changes in population composition and density, as well as to differences in growth rates of young lizards. The basic simulation was modified to test the effects of different assumptions concerning rates of death, growth and metabolism, as well as different patterns of metabolic scope. Knowledge of changes in density owing to mortality and reproduction was clearly the most critical feature of the model. Whereas these data were based on extensive field observations, the appropriateness of the respiration submodel could not be unequivocally evaluated. The use of alternative measurements of minimum metabolic rates of *Uta* resulted in estimates of annual metabolism which were three to four times higher, and of annual energy flow which were about three times higher, than those obtained with the basic simulation. No obvious rationale was available for selecting between different measurements of minimum respiratory rates. The utility and reliability of simplified models for estimating energy flow were also tested. Values of R, E, P and energy flow were regressed on various population state variables. Values of P and E were most significantly correlated with biomass while R was highly correlated with densities. For the three years in question annual energy flow (kcal/ha) could be expressed as 2.2 (April + November biomass in g/ha) + 16 N + 102.3, with N the average daily density/ha for each year. A simplified model for estimating R, based on mean monthly densities, yielded estimates of annual adult respiration within 5% of those obtained with the basic simulation. This model failed, however, to distribute the annual energy of metabolism accurately within months. Our findings indicate that *Uta stansburiana*, and possibly other numerous and short-lived lizards, are of greater significance in the energy dynamics of natural communities than has heretofore been appreciated. It is also possible to develop relatively simple models of *Uta* energy flow (including R, E and ΔB) based on monthly changes in population states. (Authors) *Keywords:* IBP*, reptile*, ecology/ecosystem*, life history*, methods*

749 **TURNER, F.B., P.A. MEDICA, and D.D. SMITH. 1973. Reproduction and Survivorship of the Lizard, *Uta stansburiana*, and the effects of winter rainfall, density and predation on these processes. US/IBP Desert Biome Res. Memo. 73-26. Utah State University, Logan, 19 pp.**

Survival and reproduction by the iguanid lizard, *Uta stansburiana*, was investigated in 0.4 ha enclosures near Mercury, Nye County, Nevada. The study was formally commenced in the spring of 1972, but for some aspects, observations have been drawn from three preceding years. Mayhew's hypothesis relating egg production by certain insectivorous lizards to production of winter annuals was examined in detail. Artificial augmentation of normal winter rainfall by the addition of 5 cm of water during November was shown to increase dry matter production by winter annuals (ca 8 g/m^2 vs. 0.5 g/m^2 in 1971-1972). Analysis of variance showed that lizards occupying irrigated areas registered greater body weight gains than those in non-irrigated areas in both years. This is interpreted as direct evidence of an increase of insect food for, *Uta* as a result of additional winter rainfall. The number of egg clutches produced was greater after irrigation during November -- approximately one additional clutch of eggs was produced by female *Uta* occupying irrigated areas during 1970 and 1972. Older females generally produced more clutches than yearling females. Clutch frequency (F) can be roughly predicted from November - December rainfall in cm (R): F (yearlings) = 0.34R + 0.47, F (older) =0.26R + 1.55. Analysis of variance involving the size of 46 first clutches laid in 1970 indicated pronounced effects due to both age and irrigation. A similar analysis based on first and second clutches laid in 1972 indicated the age, effect, but showed no influences owing to irrigation or density. Mean clutch size of yearling *Uta* was 3.19 in 1970, 3.65 in 1972. Mean clutch size of older *Uta* was 4.20 and 4.39, respectively, in these two years. Annual survival of yearling and older *Uta* during three years was analyzed. There appeared to be differences between years. Survival of male and female *Uta* was very similar, but yearling lizards survived somewhat better than older individuals. When data from three years were combined there was an inverse relationship between percent annual survival (S) and density (d, per ha): S = -0.0057d + 0.68. There is some suggestion that rates of survival observed in 0.4 ha enclosures may not be an adequate measure of mortality experienced in unrestrained populations. (Authors) *Keywords:* IBP*, climate*, reptile*, ecology/ecosystem*, life history*

750 **TURNER, F.B., P.A. MEDICA, and D.D. SMITH. 1974. Reproduction and Survivorship of the Lizard, *Uta stansburiana*, and the effects of winter rainfall, density and predation on these processes. US/IBP Desert Biome Res. Memo. 74-26. Utah State University, Logan, 12 pp.**

Survival and reproduction by the iguanid lizard, *Uta stansburiana*, were investigated in six 0.4-ha enclosures near Mercury, and in four plots in Rock Valley. Both study areas are in Nye County, Nevada. Reproduction during the spring and early summer of 1973 was conspicuously greater than in 1972. Mean total egg production by females in 1973 was estimated to be roughly twice that in the preceding year. These observations were in general accord with previous investigations linking egg production to winter rainfall. Rainfall during January and February 1973 was apparently important in promoting growth and production of winter annuals and subsequent egg production by Uta. When data from three years were analyzed, including results from irrigation experiments in 1969 and 1971, clutch frequency (F) was best predicted in terms of F (yearlings) = 1.00R + 0.17, F (older) = 0.948 + 0.90. Analyses of clutch size showed the usual difference between yearling and older females, but no unequivocal effects correlated with density. Mean clutch size of yearling *Uta* was 3.91 in 1973; for older *Uta* it was 5.07. Some simplifying assumptions were developed to serve as a guide for modeling egg production by *Uta*. Mean clutch size of older females in March and April C_a was assumed to range from 3 to 5 and to be a linear function of R (as defined above): C_a=0.33R+3. The relationship between mean clutch sizes of older and yearling females and the general decline in clutch size as the reproductive season advances was also considered. Annual survival of adult *Uta* in six 0.4-ha enclosures showed an inverse correlation with density (d) when data from three years were combined: S_0 = -0.0042d + 0.58. Analysis of 1972-73 data relating to hatchling survival did not reveal a significant inverse correlation, although when hatchling survival was regressed on total egg production the correlation coefficient was negative (-0.56). Survival of hatchling *Uta* over the first eight months of life and annual survival of older *Uta* were analyzed, both in the presence and absence of the predatory leopard lizard (*Crotaphytus wislizenii*). Survival of hatchlings from the summer of 1972 to the spring of 1973 was about 43% in 0.4-ha enclosures where leopard lizards were absent. In other larger plots where leopard lizards were present, hatchling survival was about 15% . Similarly, survival of adult *Uta* (≥ eight months of age) from March to August 1973 was about 55% in six 0.4-ha enclosures and 40% in a larger area from which leopard lizards were excluded. In another enclosure with about 2.5 leopard lizards per hectare, survival was only 15%. We suggest that the apparent predation effect on *Uta* survival may explain previously noted differences between survival in 0.4-ha enclosures (without leopard lizards) and larger areas in Rock Valley where these predatory lizards have been present. *Uta* survival in the presence of leopard lizards could be related to survival without leopard lizards by multiplying the latter by a factor (Z) based on the spring density of leopard lizards, D. For example: Z = $_e$-0.4D. Annual survival of yearling *Uta* (eight months old) is better than that of older lizards. If overall survival of adults (≥ eight months old) adjusted for predation is S_x, annual survival of yearlings (S_y) may be estimated as 1.087 S_x and annual survival of older Uta (S_a) as 0.68S_y. (Authors) *Keywords:* IBP*, climate*, reptile*, ecology/ecosystem*, life history*

751 TURNER, F.B., R.H. ROWLAND, and R.A. WOOD. 1966. Nuclear engineering and wildlife: radioactivity in jackrabbits after the Sedan test. Journal of Wildlife Management 30:433-443.

After the Sedan thermonuclear test of July, 1962, at the Nevada Test Site, black-tailed jackrabbits (*Lepus californicus*) were collected from two areas within the local fallout pattern. The maximal tissue burdens measured were 9,700 nc of iodine-131 per gram of thyroid, 3.6 nc of cesium-137 per gram of muscle ash, 25.3 nc of strontium-89 per gram of bone ash, and 0.3 nc of strontium-90 per gram of bone ash. Estimated infinite doses to thyroids from iodine-131 were as high as 4,000 rems. The muscle of jackrabbits did not contain enough cesium-137 to render the meat unsafe; a person consuming one of the most highly contaminated rabbits might have incorporated 5 to 10 nc of cesium-137. Possible biological effects of the Sedan test in areas beyond the zone of closein destruction are considered, and some problems in evaluating the ecological impact of nuclear engineering on wildlife resources are discussed. (Authors) *Keywords:* mammal*, radiation*

752 TURNER, F.B., G.A. HODDENBACH, P.A. MEDICA, and J.R. LANNOM. 1970. The demography of the lizard, *Uta stansburiana* Baird and Girard, in southern Nevada. Journal of Animal Ecology 39:505-519.

Between 1966 and 1967 populations of *U. stansburiana* in southern Nevada increased about 40%. Over the next year they declined by about 50%. These changes are explained in terms of annual differences in fecundity and survival. Most females laid 5 clutches of eggs in 1966, but only 2 or 3 clutches in 1967. Adult survival between 1966 and 1967 was better than during the following year. The capacity for increase r_c was estimated as 0.0327/mo., and cohort generation time, T_c as 15.32 mo. from the 1966-67 data. Data from other natural populations of lizards are reviewed and the inferred net reproductive rates (R_o) compared with the history of the populations. Problems in the study of lizard populations are discussed, particularly the difficulty in assessing egg production by species laying several clutches of eggs each season. (Authors) *Keywords:* reptile*, life history*

753 TURNER, F.B., B. KOWALEWSKY, R.H. ROWLAND, and K.H. LARSON. 1964. Uptake of radioactive material from a nuclear reactor by small mammals at the Nevada Test Site. Health Physics 10:65-68.

Studies were made on the degree to which radioactive isotopes released from a nuclear reactor (Kiwi-A) test contributed to the tissue burdens of rabbits and rats. Gross beta activities in tissues of rabbits collected within the fallout pattern after the test (July) were consistently greater than activities in rabbits analyzed before the test (February). However, muscles from rabbits collected outside the pattern in July showed significantly greater radioactivity than February samples. This suggests that the increases in gross beta activity can be ascribed to stratospheric fallout. The gross beta activities of the muscle, bones, skins, and gastrointestinal tracts (and contents) of the July rodents were higher than in the specimens collected in February. Gross beta activities of thyroids collected in July ranged from 18 to 3,280 disintegrations per minute for rodents and 133 to 1,740 disintegrations per minute for rabbits. (PCH) *Keywords:* mammal*, radiation*

754 **TURNER, F.B., J.R. LANNON, H.J. KANIA, and B.W. KOWALEWSKY. 1967. Acute gamma irradiation experiments with the lizard *Uta stansburiana*. Radiation Research 31:27-35.**

Five experiments with young and adult *Uta stansburiana* indicate that, when this species is exposed to acute Co-60 radiations, the $LD_{50}(_{30})$ ranges from about 1,700 to 2,200 R (with standard deviations of the order of 300 to 400 R). Adult males were shown to be more radiosensitive than adult females, but no sex differences were observed in an experiment with animals 3 to 40 months of age. Doses were administered at 100 R/min and 200 R/min; the latter dose rate resulted in shorter survival times and (among adult males) a lower $LD_{50}(_{30})$. (Authors) *Keywords:* reptile*, radiation*

755 **TURNER, F.B., J.R. LANNOM, Jr., P.A. MEDICA, and G.A. HODDENBACH. 1969. Density and composition of fenced populations of leopard lizards (*Crotaphytus wislizenii*) in southern Nevada. Herpetologica 25:247-257.**

Leopard lizards exist in Rock Valley, Nevada, at low densities (12/acre) sustained by good adult survival (roughly 50% per annum) and maximal life-spans of at least 7-8 years. Among individuals more than 8 months of age, male survivorship appears to be superior to that of females. Thus, although the sex ratio among hatchlings is about even, there appear to be more adult males than females in our area. Biomass estimates over a period of 5 years in three 20-acre areas ranged from 17.6 g/acre to 47.8 g/acre. Females do not ordinarily reproduce until 21-23 months of age, but in 1966 a few females reproduced when 9-11 months old. One clutch of eggs per year is typical, but occasionally two clutches may be laid (1965), and in 1964 there was no reproduction. (Authors) *Keywords:* reptile*, life history*

756 **TURNER, F.B., P.A. MEDICA, K.W. BRIDGES, and R.I. JENNRICH. 1982. A Population Model of the Lizard *Uta Stansburiana* in Southern Nevada. Ecological Monographs 52(3):243-259.**

Population densities, reproduction, and survival of the lizard *Uta stansburiana* were measured at the Nevada Test Site in southern Nevada, USA, between 1964 and 1974. These data were used to develop a model of the population dynamics of this species. Results of irrigation experiments in 0.4-ha enclosures near Mercury, Nevada, were used to formulate multiple-regression equations predicting frequency and size of clutches laid by two age-classes of females in terms of winter rainfall, March air temperatures, and *Uta* population density. Densities of *Uta* in these enclosures were manipulated, and age-specific survival modeled in terms of spring densities of *Uta*. Experiments in which an important predator on *Uta* (the leopard lizard, *Crotaphytus wislizeni*) was removed from enclosures were used to estimate the influence of the predator on basic survival rates of hatchling and older *Uta*. The model was generally developed from data acquired in the small enclosures, but predictions were compared with actual observations of changes in *Uta* populations in Rock Valley (19 km west of Mercury, Nevada) between 1966 and 1972. Agreement between model predictions and actual numbers was fair. The model predicted a decrease in density from 1966 to 1967, but numbers of *Uta* actually increased conspicuously at this time. This was the only major discrepancy between predictions and observations. The observed mean spring density (d) between 1967 and 1972 was 41.4 *Uta*/ha (Sr = 20.8), while the model predicted a mean density of 37.8 *Uta*/ha (SD = 13.6). Observed and predicted mean proportions of yearlings in spring populations were identical (0.78). The basic version of the model estimated different survival rates for two age-groups of adult *Uta*. A simpler version of the model, using a common survival rate for both age-groups, gave predictions essentially identical with those of the basic model. Other tests of the basic model showed it to be most sensitive to changes in winter rainfall and predation pressure, much less so to air temperatures. Fifteen and 30-yr synthetic sequences of predator densities were used to examine model stability over longer periods of time. When predator densities were drawn randomly from distributions with a mean of 2 individuals/ha, model populations exhibited lower mean numbers and amplitudes than actually observed during 9 yr in Rock Valley. The basic model included three density-dependent parameters: clutch frequency, clutch size, and adult survival. The model was modified so that (1) egg production was density independent, while adult survival was not; (2) adult survival was density independent, but egg production was not; and (3) there was no density dependence in the model. Thirty-year tests showed that cases 1 and 2 did not differ markedly from the basic model, although the removal of one density-dependent constraint resulted in slightly higher mean densities. In case 3, the model lacked stability and predicted numbers increased to unrealistic levels within 5 yr. We conclude that processes relating to egg production were modeled more effectively than those influencing survival, and that improvement of the model will depend on more detailed studies of the impact of predation on age-specific survival rates of *Uta*. (Authors) *Keywords:* reptile*, life history*, ecology/ecosystem*, methods*

757 **TURNER, F.B., P.A. MEDICA, R.I. JENNRICH, and B.B. MAZA. 1982. Frequencies of broken tails among *Uta stansburiana* in southern Nevada and a test of the predation hypothesis. Copeia 4:835-840.**

Frequencies of broken tails among hatchling (1-4 months), yearling (7-12 months) and 2-year old *Uta stansburiana* (19-24 months) in southern Nevada were examined for the years 1966-1973. Frequencies among males and females in the two older age groups did not differ significantly. The frequency of broken tails in hatchlings (0.06) was lower than that in yearlings (0.30), which was, in turn, lower than that in 2-year old *Uta* (0.51). Break frequencies among yearlings varied from 0.26 to 0.37 in different years, while frequencies among 2-year olds varied from 0.33 to 0.64. These differences were not statistically significant. Among hatchling *Uta*, tail break frequencies ranged from as low as 0.029 (1971) to as high as 0.099 (1966), and differences between years were highly significant. Tail break frequencies in all age groups were analyzed in terms of spring densities of *Uta* and of an important predator (*Crotaphytus wislizenii*). Tail breaks in yearling and 2-year old *Uta* were not correlated with either density variable. Tail-break frequencies of hatchling *Uta* were significantly correlated with predator density ® = 0.88), and multiple regression analysis (with densities of both lizards as independent variables) yielded an R^2 of 0.80. This is the first test of the tail break hypothesis using cohorts of known-aged lizards. The findings suggest, but do not prove, a relationship between leopard lizards and hatchling *Uta* which does not persist among other *Uta*. (Authors) *Keywords:* reptile*, ecology/ecosystem*, life history*

758 **TURNER, F.B., P.A. MEDICA, J.R. LANNOM, Jr., and G.A. HODDENBACH. 1969. A demographic analysis of continuously irradiated and nonirradiated populations of the lizard, *Uta stansburiana*. Radiation Research 38:349356.**

A natural population of the lizard *Uta stansburiana* occupying a fenced 20 acre area in southern Nevada has been exposed to essentially continuous gamma irradiation since February 1964. Tissue doses averaged about 2 rads/day. Nonirradiated populations occupying three adjoining 20-acre areas have also been investigated. Five years of sampling data drawn from the experimental and control populations showed no statistically significant differences in the sex ratios. Comparisons of maximal life span (44 months) and X^2 tests of age distributions did not indicate a statistically significant difference between the experimental and untreated populations, but the tests were not sensitive to small changes in the proportions of individuals living to the age of 44 months. Both the 59% increase of the irradiated population between 1966 and 1967 and the 43% decline between 1967 and 1968 were generally matched by corresponding changes in the three untreated areas. (Authors) *Keywords:* reptile*, life history*, ecology/ecosystem*, radiation*

759 **TURNER, F.B., P.A. MEDICA, J.R. LANNOM, Jr., and G.A. HODDENBACH. 1969. A demographic analysis of fenced populations of the whiptail lizard, *Cnemidophorus tigris*, in southern Nevada. Southwestern National 14:189-202.**

Between 1964 and 1967, spring densities of *Cnemidophorus tigris* in four study areas in southern Nevada ranged from 3-8 per acre. Estimated biomass ranged from around 43 to 114 g/acre. The sex ratio was 1:1. Minimal annual survival of adults was 54-60%, and life-spans of at least 7 years are postulated. An undetermined proportion of mature females laid two clutches of eggs in 1965, but the general pattern was one clutch of 2-4 eggs per year. Large females produced more eggs than small ones. Occasionally females 9-10 months of age laid eggs, but sexual maturity normally was attained at about 21 months. By assuming that all mature females laid two egg clutches in 1965 our fecundity estimates could be approximately reconciled with the observed size and age composition of populations in the spring of 1966. Possible compensatory errors in this analysis are discussed. (Authors) *Keywords:* reptile*, ecology/ecosystem*, life history*

760 **TURNER, F.B., P. LICHT, J.D. THRASHER, P.A. MEDICA, and J.R. LANNOM, Jr. 1973. Radiation-induced sterility in natural populations of lizards (*Crotaphytus wislizenii* and *Cnemidophorus tigris*). In: (Nelson, D.J., Ed.) *Radionuclides in Ecosystems*, Proceedings of the Third National Symposium on Radioecology (CONF-710501), pp. 1131-1143.**

Leopard lizards (*Crotaphytus wislizenii*) and whip-tail lizards (*Cnemidophorus tigris*) have been exposed to gamma radiation in a fenced 20 acre area since January 1964. Free-air exposure rates over most of the area were around 4-6 R/day. Average annual tissue doses have been estimated with implanted lithium fluoride microdosimeters at 400-500 rads/year for *Crotaphytus* and about half this for *Cnemidophorus*. Demographic data and failure of mature female *Crotaphytus* in the irradiated area to assume typical reproductive coloration indicated absence of reproduction by this species in 1967 and

1968. Three female leopard lizards taken from the irradiated plot in May and June 1969 exhibited complete regression of ovaries, undeveloped oviducal walls, and hypertrophied fat bodies. One of three irradiated males collected at the same time was sterile. All of 20 control individuals taken in 1969 exhibited ovaries, oviducts, testes, and epididymides normal for the season. The first sterile female *Cnemidophorus* was collected in June 1969. Of four more females taken from the irradiated area in June 1970, three lacked ovaries; one had ovaries and had recently laid eggs. Three males from the irradiated area in 1970 did not differ in sexual condition from three control males. Experimental administration of follicle-stimulating hormone to the three apparently sterile *Cnemidophorus* females collected in 1970 had no effect on oviducal growth. The sterility observed in both species is attributed to long-term exposure to gamma radiation. Reproduction by another lizard, *Uta stansburiana* occupying the irradiated area has apparently been normal since the beginning of the experiment. The difference in response of *Uta* and the other two species is attributed to their markedly different life-spans and demographic regimes. (Authors) *Keywords:* reptile*, life history*, radiation*

761 U.S. DEPARTMENT OF ENERGY. 1991. Biological Assessment of the Effects of Activities of the U.S. Department of Energy Field Office, Nevada on the Threatened Desert Tortoise. U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 47.

This report was prepared to address the potential impacts to the desert tortoise resulting from planned DOE/NV activities that will occur on the NTS from 1991-1995. It presents measures that DOE will implement to mitigate and compensate for those impacts. This report is to provide the Fish And Wildlife Service with information needed to complete a Biological Opinion for DOE activities on the NTS. The report provides a description of the natural history of the NTS including biological resources, climate, physiography and geographical setting. The distribution and abundance of desert tortoises on the NTS are described. A description of proposed activities are presented and possible effects of those activities on desert tortoises. Finally is describes mitigation plans to offset possible adverse effects. (WKO) *Keywords:* management*, desert tortoise*, perturbations*, ecology/ecosystem*

762 U.S. DEPARTMENT OF ENERGY. 1996. Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada. Volume 1. DOE/EIS 0243, DOE Nevada Field Office, Las Vegas, NV.

This sitewide EIS evaluates the potential environmental impacts of four possible land-use alternatives being considered for the Nevada Test Site (NTS), the Tonopah Test Range, and the formerly operated DOE sites in the state of Nevada: the Project Shoal Area, the Central Nevada Test Area, and portions of the Nellis Air Force Range Complex. Three additional sites in Nevada-Eldorado Valley, Dry Lake Valley, and Coyote Spring Valley are evaluated for co-location of solar energy production facilities. The four alternatives include Continue Current Operations (No Action, continue to operate at the level maintained for the past 3 to 5 years); Discontinue Operations (discontinue operations and interagency programs); Expanded Use (increased use of NTS and its resources to support defense and nondefense programs); and Alternate Use of Withdrawn Lands (discontinue all defense-related activities at NTS; continue waste management operations in support of NTS environmental restoration efforts; expand nondefense research). Environmental impacts were assessed for each alternative by analyzing, to the extent possible, the discrete and cumulative environmental impacts associated with Defense Waste Management, Environmental Restoration, Nondefense Research and Development, and Work for Others Programs. A framework for a Resource Management Plan is included as Volume 2 of this EIS and represents the development of an ecosystem based planning process closely integrated with the National Environmental Policy Act process. This EIS, among other things, analyzed the impacts of transportation of low level waste, and site characterization activities related to the Yucca Mountain Project but did not analyze the suitability of the site as a repository. This EIS does not analyze the suitability of the Yucca Mountain site as a repository as this is an action beyond the scope of the EIS. The Preferred Alternative is identified as Expanded Use plus the public education activities from Alternate Use of Withdrawn Lands. Volume 3 of this EIS contains the public comments and the responses to the comments. (Authors) *Keywords:* management*, geology*, hydrology*, climate*, soil property*, radionuclide inventory*, perturbations*, sensitive animals*, sensitive plants*, wetlands*, vegetation*, invertebrate*, vertebrate*, ecology/ecosystem*, radiation*

763 U.S. DEPARTMENT OF ENERGY. 1999. Nevada Test Site Resource Management Plan. DOE/NV–518, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV.

The Nevada Test Site (NTS) Resource Management Plan (RMP) describes the NTS Stewardship Mission and how its accomplishment will preserve the resources of the ecoregion while accomplishing the objectives of the mission. The plan was developed using the principles of ecosystem management and identifies goals for managing the resources, organizational roles and responsibilities, and resource limitations. The plan also identifies the data management tools, monitoring plans, and adaptive management processes that will be used to facilitate informed decision making related to the use of the natural and manmade resources at the NTS. The NTS Stewardship Mission is to manage the land and facilities at the NTS as a unique and valuable national resource. *The United States Department of Energy, Nevada Operations Office* (DOE/NV) *Strategic Plan* (DOE/NV, 1998) defined a land use policy that supports national security missions as the primary NTS mission. The land use policy recognizes that the transition from an active underground nuclear weapons testing program to a program of stewardship of the enduring nuclear stockpile and test readiness provides opportunities to make portions of the NTS available for alternate uses. The RMP has defined goals for twelve resource areas based on the principles of ecosystem management. These goals were established using an interdisciplinary team of DOE/NV resource specialists with input from surrounding land managers, private parties, and representatives of Native American governments. The overall goal of the RMP is to facilitate improved NTS land use management decisions within the Great Basin and Mojave Desert ecoregions. *Keywords:* management*, geology*, hydrology*, soil property*, desert tortoise*, sensitive animals*, sensitive plants*, wetlands*

764 U.S. DEPARTMENT OF ENERGY. 2000. Nevada Test Site Annual Site Environmental Report for Calendar Year-1999. DOE/NV11718–463, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV.

This document presents the results of the Department of Energy, Nevada Operations Office environmental monitoring programs at the Nevada Test Site. This report is published yearly for public information. The Annual Site Environmental Report (ASER) includes results of monitoring activities, actions required to comply with environmental regulations, and explanations of long-term studies that assess environmental conditions at the NTS. Quality assurance programs, which are also used to ensure the validity and accuracy of the monitoring data, are also included in the report. Radiological monitoring includes air and water surveillance and routine sampling of NTS biota. Radiological data are used to estimate human dose from NTS activities. Non-radiological compliance activities and monitoring of the environment is also reported. Analysis of the 1999 data demonstrate that DOE/NV activities and programs at the NTS met radiation protection standards established by DOE/NV and the Environmental Protection Agency (EPA). Therefore, exposures above normal background levels to the general public who reside in the vicinity of the NTS were negligible. No federal or contractor employee received an exposure dose greater than the international standards set for radiation workers. *Keywords:* radionuclide inventory*, desert tortoise*, wetlands*, sensitive animals*, sensitive plants*, vegetation*, vertebrate*, radiation*

765 U.S. DEPARTMENT OF ENERGY. 2001. Nevada Test Site Annual Site Environmental Report for Calendar Year-2000. DOE/NV117118–605, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV.

This document presents the results of the Department of Energy, Nevada Operations Office environmental monitoring programs at the Nevada Test Site. This report is published yearly for public information. The Annual Site Environmental Report (ASER) includes results of monitoring activities, actions required to comply with environmental regulations, and explanations of long-term studies that assess environmental conditions at the NTS. Quality assurance programs, which are also used to ensure the validity and accuracy of the monitoring data, are also included in the report. Radiological monitoring includes air and water surveillance and routine sampling of NTS Biota. Radiological data are used to estimate human dose from NTS activities. Non-radiological compliance activities and monitoring of the environment is also reported. Analysis of the 2000 data demonstrate that DOE/NV activities and programs at the NTS met radiation protection standards established by DOE/NV and the Environmental Protection Agency (EPA). Therefore, exposures above normal background levels to the general public who reside in the vicinity of the NTS were negligible. No federal or contractor employee received an exposure dose greater than the international standards set for radiation workers. (CAW) *Keywords:* radionuclide inventory*, desert tortoise*, wetlands*, sensitive animals*, sensitive plants*, vegetation*, vertebrate*, radiation*

766 U.S. ENVIRONMENTAL PROTECTION AGENCY. 1978. Bibliography of the Animal Investigation Program. DOE/NV Accession #NV0013693, U.S. Environmental Protection Agency, Washington, D.C.

This document is simply a list of publications, EPA annual reports, and Nevada Applied Ecology Group progress reports related to the Nevada Test Site Animal Investigation Program. It includes a list of associated reports pertaining to the Nevada Test Site Experimental Farm. Sixty-nine references are listed, and the bibliography was produced in January 1978. (CAW) *Keywords:* EPA*, NAEG*, bibliography*

767 U.S. FISH AND WILDLIFE SERVICE. 1992. Final Programmatic Biological Opinion for Nevada Test Site Activities.

File No. 1-5-91-F-225, Fish and Wildlife Service Nevada State Office, Reno, Nevada.

This Opinion was issued to the U.S. Department of Energy, Nevada Operations Office (DOE/NV) for activities planned on the NTS for fiscal years 1992 through 1995. It concludes that proposed activities are not likely to jeopardize the continued existence of the Mojave population of the desert tortoise and that no critical habitat would be destroyed or adversely modified. This Opinion describes areas and projects excluded from the Opinion, NTS proposed activities covered under the Opinion, mitigation measures proposed by DOE/NV, the status of the species, critical habitat and recovery areas, effects of proposed actions on the speciese, the extent of incidental take of the species allowed, and terms and conditions which must be followed by DOE/NV to comply with the Opinion. (CAW) *Keywords:* management*, perturbations*, desert tortoise*, ecology/ecosystem*

768 **U.S. FISH AND WILDLIFE SERVICE. 1996. Final Programmatic Biological Opinion for Nevada Test Site Activities. File No. 1-5-96-F-33, Fish and Wildlife Service Nevada State Office, Reno, Nevada.**

This Opinion was issued to the U.S. Department of Energy, Nevada Operations Office (DOE/NV) for activities planned on the NTS within the next 10 years. It concludes that proposed activities are not likely to jeopardize the continued existence of the Mojave population of the desert tortoise and that no critical habitat would be destroyed or adversely modified. Proposed actions on the Nevada Test Site were described under Alternative 3 of the Draft Environmental Impact Statement provided to the USFWS. This Opinion describes areas and projects excluded from the Opinion, NTS Programs covered under the Opinion, mitigation measures proposed by DOE/NV, the status of the species, critical habitat and recovery areas, effects of proposed actions on the speciese, the extent of incidental take of the species allowed, and terms and conditions which must be followed by DOE/NV to comply with the Opinion. (CAW) *Keywords:* management*, perturbations*, desert tortoise*, ecology/ecosystem*

769 **U.S. FISH AND WILDLIFE SERVICE. 1997. Final Biological Opinion for Reinitiation of Formal Consultation for Yucca Mountain Site Characterization Studies. File No. 1-5-96-F-307R. Fish and Wildlife Service Nevada State Office, Reno, NV.**

This Opinion was issued to the U.S. Department of Energy Yucca Mountain Site Characterization Office (DOE/YMSCO) for activities planned within the Yucca Mountain study area over the next xxx years. It concludes that proposed activities are not likely to jeopardize the continued existence of the Mojave population of the desert tortoise and that no critical habitat would be destroyed or adversely modified. This Opinion describes areas and projects excluded from the Opinion, NTS Programs covered under the Opinion, mitigation measures proposed by DOE/NV, the status of the species, critical habitat and recovery areas, effects of proposed actions on the speciese, the extent of incidental take of the species allowed, and terms and conditions which must be followed by DOE/YMSCO to comply with the Opinion. (CAW) *Keywords:* YMSCO*, management*, perturbations*, desert tortoise*, ecology/ecosystem*

770 **U.S. GEOLOGICAL SURVEY. 2001. Monitoring of Ecosystem Dynamics in the Mojave Desert: The Beatley Permanent Plots. USGS Fact Sheet FS-040-01, U.S. Department of the Interior, U.S. Geological Survey.**

This fact sheet presents work initiated by the U.S. Geological Survey in 2000 to monitor long-term changes in vegetation at 68 permanent Mojave Desert study plots established on the Nevada Test Site in 1962 by Dr. Janice C. Beatley. Historic data and photographs of these plots from the 1960's have been compared to current photographs to reveal important changes over time. From these plots, information is being generated about disturbance-recovery regimes, climate change, non-native plant invasions, and plant/animal interactions through synthesis of data collected over a half century. These plots are also generating significant ecological hypotheses that will be tested using field-scale experiments. This Fact Sheet gives a description of the Beatley permanent plots and their usefulness for addressing several important ecological questions. (CAW) *Keywords:* climate*, perturbations*, invasive species*, vegetation*, invertebrate*, vertebrate*, ecology/ecosystem*

771 **VARNEY, D.M., and W.A. RHOADS. 1977. Chronic Radiation Induced Chromosomal Aberrations in Native Shrubs at Nevada Test Site. In: *Transuranics in Natural Environments*. White, M.G., and P.B. Dunaway (Eds.). NVO-178, Nevada Applied Ecology Group, U.S. Energy Research & Development Administration, Las Vegas, NV. pp. 351-378.**

Radiation effects at the morphological and phenological level within vegetation at NTS have been looked for almost from the start of nuclear testing in Nevada, and have, within the last decade been described both for areas contaminated with

nuclear debris and for the vicinities of experimental radiation sources. Radiation effects at the chromosomal level of plant organization in radiation contaminated natural environments apparently have neither been sought nor observed. *Artemisia spinescens* shrubs from Site D, Area 11, Plutonium Valley NTS which have been irradiated since 1956 with uncertain doses estimated to range from 35 R to 140 R for a ten year period proved to have chromosomes quite suitable for microscopic examination. Meiotic pollen mother cells from *A. spinescens* showed, among seven classes of chromosome aberrants, 14.2% aberrants chromosomes compared to 3.8% from plants about one mile south outside the Plutonium Valley enclosure where background radiation levels occurred. These values were not statistically significant at conventionally accepted levels of significance; however when the highest percentage occurrence in each population was omitted, the difference was significant at the 95% level. For comparison two other shrub species from UCLA's Rock Valley experimentally irradiated plot, also chronically irradiated at 2.5 to 4.8 R/day since 1964 to doses very much higher than those at Site D were also investigated. Both species showed chromosome aberrations and in one species, *Krameria parvifolia*, the difference in occurrence of chromosome aberrants was different statistically for the higher radiation doses. The same kinds of chromosome aberrants were noted for all species studies and these were the kinds of aberrants noted as resulting from experimental radiation doses in the laboratory. (Authors) *Keywords:* NAEG*, perennial plants*, physiology*, radiation*

772 VOLLMER, A.T., and S.A. BAMBERG. 1975. Response of the Desert Shrub *Krameria parvifolia* after Ten Years of Chronic Gamma Irradiation. Radiation Botany 15:405-409.

A northern Mojave Desert shrub community was irradiated by a ^{137}Cs source for a ten-year period. Leaf and fruit production, cover, and percent live stem of *Krameria parvifolia* shrubs were found to respond significantly to a radiation gradient with exposure rates ranging from 0- 1 to 10 R/day. Fruit and leaf production were greatly reduced at exposures over 6 R/day. Above 7 R/day 16% of the shrubs were dead compared to 1 -2% in a non-irradiated area. Reduced cover, density and live stem values indicate a trend toward a lower status of *Krameria* in the community at cumulative exposures above 25 kR. Observations indicate that an equilibrium in response to irradiation has not yet occurred. Radiosensitivity of *K. parvifolia* is attributed in part to its phenology. (Authors) *Keywords:* perennial plants*, life history*, ecology/ecosystem*, ecology/ecosystem*, radiation*

773 VOLLMER, A.T., F. AU, and S.A. BAMBERG. 1977. Distribution of Microorganisms in Desert Soil. US/IBP Desert Biome Res. Memo. 76-31. Utah State University, Logan, 5 pp.

Population estimates of fungi, bacteria and actinomycetes in desert soil were determined with respect to soil depth and distance to shrubs. In general, the highest number of microbes was found at the shrub base and the lowest number in the interspaces. (Authors) *Keywords:* IBP*, microbiota*, ecology/ecosystem*

774 VOLLMER, A.T., F.H.F. AU, and S.A. BAMBERG. 1977. Observations on the Distribution of Microorganisms in Desert Soil. Great Basin Naturalist 37:81-86.

Population estimates of fungi, bacteria, and actinomycetes in desert soil were determined with respect to soil depth and distance from shrubs. In general the highest numbers of microbes were found at the shrub base: the lowest numbers were found in the interspaces. While the total number of organisms usually declined in deeper soil, the relative importance of the actinomycetes increased. These population trends are attributed to substrate availability and utilization and interspecific interactions. As the soils became drier and warmer the total number of microorganisms decreased. Mold populations remained at about the same level during the study. While the numbers of both bacteria and actinomycetes declined, the relative importance of the actinomycetes increased. (Authors) *Keywords*: soil property*, microbiota*, ecology/ecosystem*

775 VOLLMER, A.T., A. WALLACE, J.W. CHA, and T. HARTSOCK. 1976. Plant Productivity and Nutrient Interrelationships of Perennials in the Mohave Desert. US/IBP Desert Biome Res. Memo. 76-6. Utah State University, Logan, 6 pp.

Various studies of aspects of perennial plant productivity, most of which relate to the carbon budget of the northern Mohave Desert, were continued in 1975. Respiration rates of the reproductive parts of plants were determined for five common Mohave Desert shrubs. They were determined at five different developmental stages and at four different temperatures for each (10, 20, 30, 40 C). The rates increased with temperature generally and varied from < 0.1 to > 5 µg C g dry wt^{-1} hr^{-1}. The late fruit stage usually, but not always, gave the lowest rate. Attempts were made to determine soil respiration by measurement of the efflux of CO_2 from the soil. For several days after watering of soil in August, the CO_2

efflux rate was greatly increased. The cloud-cover effect was measured on gas exchange rates. For *Larrea tridentata*, *Atriplex canescens* and *Ambrosia dumosa*, there was a very pronounced effect of cloud cover when the light intensity was in the range of 0.2 to 0.4 cal · cm^{-2} · min^{-1}. Distribution of ^{14}C in two *Larrea tridentata* plants was determined 16 months after exposure of the leaves to $^{14}CO_2$. After 16 months, 13.7 and 16.8% of the original ^{14}C was retained in the plants. More ^{14}C was in stems and leaves than in roots. The below-ground:above-ground ratio for ^{14}C was 0.56 as compared to 1.85 for biomass. The organic debris in the soil below the shrubs and which was floated out by $MgSO_4$ did not contain ^{14}C, but the very fine roots in the samples did in 90% of the cases. The results helped to determine what are to be considered as roots in this desert *area*. *Ambrosia dumosa* grown in solution culture were exposed to $^{14}CO_2$ to label photosynthate and distribution among leaves, stems and roots after 4, 24 and 48 hr. For all sampling periods, the highest levels of ^{14}C were found in leaves and the lowest in roots. (Authors) *Keywords:* IBP*, perennial plants*, physiology*

776 VOLLMER, A.T., B.G. MAZA, P.A. MEDICA, F.B. TURNER, and S.A. BAMBURG. 1976. The impact of off-road vehicles on a desert ecosystem. Environmental Management 1(2):115-129.

The effects of operating a four-wheel drive truck in a 9 ha area of the Mojave Desert [in Rock Valley] were evaluated. A truck was driven over the same 0.9 km track 21 times between November 1973 and May 1974. The vehicle was also driven randomly around the area (1.3 to 3.4 km) 17 times between December 1973 and May 1974. Spring densities of annual plants in ruts of the regular track (8/m^2) were less than those in control areas (46-112/m^2), but densities in randomly driven plots (39/m^2) did not differ significantly from controls. Severity of damage to shrubs was directly related to intensity of driving in the area. About 58% of shrubs growing in the regular track sustained estimated damage ranging from 81 to 100%. In randomly driven areas only 6% of shrubs were damaged to this extent, while about 61% sustained damage from 0 to 20%. Numbers and kinds of rodents in control and driven areas were similar before and after the experiment. More young rodents were trapped in the experimental plot than in the control area during July 1974, and this may have been prompted by basal sprouting of new growth by damaged shrubs. Estimates of numbers of side-blotched lizards indicated similar densities before, during, and after the experiment. Counts of whiptail lizards in control and experimental areas were the same after the experiment, but counts of gridiron-tailed lizards were much lower in the driven area. (Authors) *Keywords:* perturbations*, annual plants*, perennial plants*, reptile*, mammal*, ecology/ecosystem*

777 WALLACE, A. 1970. Water use in a glasshouse by *Salsola kali* grown at different soil temperatures and at limiting soil moisture. Soil Science 110:146-149.

Salsola kali (Russian thistle) plants were grown in soil in tanks used to control root temperatures. Moisture levels were varied and maintained for most plants at predetermined levels. Yields, water evaporated, and water transpired were measured and from these values transpiration and evapotranspiration values were calculated per unit of plant dry weight and also per unit of new plant growth. Transpiration and evapotranspiration were influenced more by soil temperature than by soil moisture. There was a tendency for increased transpirational efficiency at low soil moisture. At 10, 12, and 13% soil moisture, transpiration increased with increasing soil temperature but at 7% soil moisture it did not, indicating a physiological resistance to water movement across roots when water was limiting. (MK) *Keywords*: soil property*, invasive species*, annual plants*, physiology*

778 WALLACE, A. 1980. Soil-Plant-Animal Relationships Bearing on Revegetation and Land Reclamation in Nevada Deserts. Great Basin Naturalist Memoirs No. 4.

This volume of the Great Basin Naturalist contains 30 papers containing information which can be used either to prevent needless destruction of desert systems or to help restore disturbed lands to their original condition. The studies involved cover a period of several years. Included were years during which the International Biological Program participated in desert ecosystems studies on the NTS and those during which the Department of Energy sponsored environmental and ecological studies on the NTS. The 30 papers can be divided into six groupings. The first is a single paper describing the amazing amount of annual variability in phenology of perennial plants at NTS. The second is a group of 11 papers which describe how plant communities are put together and explain some of their attributes. The third group of five papers relates to the carbon cycle under desert conditions. The fourth group of six papers relates to soil-plant relationships of desert vegetation and mineral composition of plants. The fifth group of four papers concerns photosynthesis and transpiration processes. The sixth group of three papers relates to practical aspects of desert revegetation. (CAW) (Note: All applicable papers containing information gathered on the NTS are listed individually by author in this annotated bibliography.) *Keywords:* IBP*, perennial plants*, vegetation*, ecology/ecosystem*, life history*, nutrition/diet*, physiology*, revegetation*

779 **WALLACE, A., and R.T. ASHCROFT. 1970. Significance of vapor in plant water economy. Advancing Frontiers of Plant Sciences 26: 153-159.**

Atriplex lentiformus leaves absorbed considerable water vapor from a saturated water atmosphere and *Atriplex canescens* also absorbed a significant but smaller amount. *Larrea divaricata* absorbed a small amount only. *Lycium andersonii, Kalanchoe* sp., and *Pelargonium hortorum* neither gained nor lost water under this system. The last three species lost water more slowly when exposed to a dry atmosphere than other species. When leaves were partially desiccated before placing in 100% relative humidity, *Atriplex canescens* and *Larrea divaricata* regained much of the lost water from a saturated atmosphere. *Larrea divaricata* plants after preconditioning appeared to be able to survive for a period with water from the vapor source only. The critical answers about vapor and fog use by plants are not yet known. (Authors) *Keywords:* perennial plants*, physiology*

780 **WALLACE, A., and R.T. MUELLER. 1968. Effect of chelating agents on the availability of ^{54}Mn following its addition as carrier-free ^{54}Mn to three different soils. Soil Sci. Soc. Amer. Proceedings 32:828-830.**

Carrier-free Mn-54 was mixed into samples of three different soils and allowed to equilibrate for several days. The soils were Yolo loam (slightly acid), Hacienda loam (calcareous), and Dinuba fine sandy loam (neutral). Bush bean (*Phaseolus vulgaris* var. 'Improved Tendergreen') and corn (*Zea mays* var. 'Golden Cross Bantam') were grown in the soils with the presence and absence of various chelating agents. Yields and Mn-54 and total Mn were determined in the leaves and specific activities were calculated. After cropping, the control soils were assayed first for water soluble, then exchangeable Mn-54 and Mn, and then easily reducible or 10^{-3}M EDDHA, EDTA, DTPA, and NTA soluble Mn-54 and Mn. The Mn-54 appeared to differentially label various forms of Mn in the soil. Bush bean leaves contained more, Mn54 and Mn per plant than did corn. The specific activities of the Mn-54 in bush bean leaves were more like those for the easily reducible Mn than for other Mn forms for the three different soils but the specific activities in the corn, in contrast, were more nearly like those in the exchangeable Mn in the soils. DTPA tended to increase the amounts of both Mn-54 and Mn in plants with the Yolo and Dinuba soils with concommitant decreasing specific activity of Mn. With corn DTPA apparently added easily reducible Mn to the pool of available Mn. EDTA tended to increase uptake of the soluble and exchangeable Mn by the plants. NTA and EDDHA had little effect. (Authors) *Keywords:* soil property*, annual plants*, nutrition/diet*, physiology*

781 **WALLACE, A., and E.M. ROMNEY. 1974. Feasibility and alternate procedures for decontamination and post treatment management of Pu-contaminated areas in Nevada. USAEC Report UCLA 12-973, 90 pp.**

The feasibility and environmental impact of cleaning up Pu-contaminated areas in Nevada are discussed. The total area where the surface contamination level is above 1000 pCi/cm^2 is about 300 acres. Only a few acres are above 7,000 pCi/cm^2. Instead of considering all aspects of radioactive decontamination, the report deals primarily with findings from pertinent land area decontamination and post-management experiences which can be applied to solving Pu problems at the Nevada Test Site and the Tonopah Test Range. Previous experiences from accidental and planned releases of Pu in the environment are discussed along with those gained from nuclear fallout decontamination studies. Considerable attention is given to problems concerning revegetation of arid lands. The fragile nature of the desert is such that any drastic alteration will result in a seriously damaged ecosystem. Revegetation by natural means is difficult, if not impossible, from a practical point of view. Post-treatment management of disturbed areas is almost always necessary to insure recovery. An ideal cleanup and post-treatment procedure would be to remove the contamination, retain some of the native vegetation with sufficient soil fertility for its maintenance, and stabilize the distributed soil to protect it from wind and water erosion. Correction of the damage may require greater efforts than the decontamination, and may have more far reaching consequences than those concerned with the present status of the land. Alternate procedures are discussed such as deep plowing of the soil, a fencing program, and application of road oil to decrease resuspension which may be useful in Nevada, providing the necessary experimental work is done to test the validity of the assumptions made. Many answers to pertinent questions can be obtained from investigations conducted outside of the Pu areas. Recommendations are made for experimental work that should be done to determine the best course of action before cleanup begins. (Authors) (FMM) *Keywords:* perturbations*, vegetation*, revegetation*, radiation*

782 **WALLACE, A., and E.M. ROMNEY. 1976. Radioecology and Ecophysiology of Desert Plants at the Nevada Test Site, TID-25954, Energy Research and Development Administration.**

This document is a compilation of information meant to be a base for future studies regarding radiation effects and radionuclide and mineral cycling problems which are of interest to the Atomic Energy Commission and manipulation experiments such as those of interest to the International Biological Program. This volume also serves as a partial review of literature of topics of importance in meeting the needs of the programs listed. This information contributes to an interdisciplinary approach to some of the environmental problems encountered at the Nevada Test Site. The disciplines of soil science, plant nutrition, statistics, horticulture, and plant physiology have been freely mixed as an approach to problems which are generally considered to be in the realms of ecology. (Authors) *Keywords:* vegetation*, ecology/ecosystem*, nutrition/diet*, physiology*, radiation*

783 **WALLACE, A., and E.M. ROMNEY. 1977. Initial Land Reclamation Procedures Related to Possible Pu-Cleanup Activities at the Tonopah Test Range. In: *Environmental Plutonium on the Nevada Test Site and Environs.* White, M.G., P.B. Dunaway, and W.A. Howard (Eds.). NVO-171, Nevada Applied Ecology Group, U.S. Energy Research & Development Administration, Las Vegas, NV, pp. 65-77.**

If areas of the Tonopah Test Range (TTR) are to be used for experimental tests of procedures for clean-up of Pu contamination, there are experiences in the Great Basin Desert portions of the Nevada Test Site (NTS) which can serve as guides to reclamation and revegetation of such arid lands. Procedures which will encourage development of the grasses *Hilaria jamesii* and *Oryzopsis hymenoides*, as well as the perennial shrubs *Eurotia lanata* and *Atriplex canescens* would greatly improve the area as range land. (Authors) *Keywords:* NAEG*, perturbations*, annual plants*, perennial plants*, revegetation*

784 **WALLACE, A., and E.M. ROMNEY. 1980. The Role of Pioneer Species in Revegetation of Disturbed Desert Areas. Great Basin Naturalist Memoirs 4:31-33.**

The northern Mojave desert is characterized in part by small fertile islands in which exist individual shrub clumps each containing two or more plants. These fertile sites promote characteristic organization of both plant and animal activity in the desert. Destruction of these fertile sites makes revegetation extremely difficult because most seedlings germinate in these sites. Some pioneer species do, however, germinate and survive in the bare areas between the fertile sites. Four such species in the northern Mojave Desert are *Acamptopappus shockleyi, Lepidium fremontii, Sphaeralcea ambigua* and *Atriplex confertifolia*. These four species may have a role in starting new fertile islands. (Authors) *Keywords*: perennial plants*, nutrition/diet*, revegetation*

785 **WALLACE, A., S.A. BAMBERG, and J.W. CHA. 1974. Quantitative studies of roots of perennial plants in the Mojave desert. Ecology 55:11601162.**

Root and stem weights were obtained for 113 field samples of 10 species of perennial plants in the northern Mojave Desert in order to develop methods for determining belowground biomass under the given conditions. Root and stem weights for all were highly correlated, and linear regression in most cases adequately expressed the relationship between root weight and stem weight. Root weight for the total of all plants considered was about 45% of the sum of stem and root weights. There were species differences. The proportion that was root was generally independent of plant size. Root biomass can be estimated from stem weights for a population, for some species at least, within a possible error of ± 10% to 20%. The data were combined with stem weights by dimension analysis to calculate the belowground biomass per ha in the Rock Valley area of the Mojave Desert. (Authors) *Keywords:* perennial plants*, ecology/ecosystem*, life history*

786 **WALLACE, A., J.W. CHA, and E.M. ROMNEY. 1980. Distribution of Photosynthetically Fixed ^{14}C in Perennial Plant Species of the Northern Mojave Desert. Great Basin Naturalist Memoirs 4:192-200.**

The distribution of photosynthate among plant parts subsequent to its production is needed to fully understand behavior of vegetation in any ecosystem. The present study, undertaken primarily to obtain information on transport of assimilates into roots of desert vegetation, was conducted in the northern Mojave Desert, where the mean annual rainfall is about 10 cm. Shoots of *Ambrosia dumosa* (A. Gray) Payne plants were exposed to $^{14}CO_2$ in 1971, and the distribution of ^{14}C in roots, stems, and leaves was subsequently measured at 1 week, 2 months, and 5 months. Only about 12 percent of the ^{14}C photosynthate was stored in the root. Much of that stored in stems was available for new leaf growth. Photosynthate was labeled with ^{14}C for 24 plants representing eight species in 1972. Results showed that after 127 days the mean percentage of ^{14}C in roots as compared with the estimate of that originally fixed was 11.8; the percentage in stems was 43.8. The mean ratio of root to root plus stem for 14C was 0.212, but this value was only half that of the ratio for actual weights of these parts of field plants. The correlation coefficient for (^{14}C in roots)/(^{14}C in root + stem) X (dry wt of root)/(dry wt of root + stem) was

+0.89. Small stems were the major storage organ for the 14C. To check the validity of the ^{14}C data, root growth of eight perennial desert plants grown in the glasshouse was followed as plants increased in size. The mean percent of the whole plant that was root for eight species was 17.7 percent. The mean proportion of the increase in plant weights that went below ground for the eight species was 19.5 percent. This value is higher than the fraction of ^{14}C found below ground, and therefore the ^{14}C technique underestimates the movement of C to roots. Results of an experiment designed to test the value of the ^{14}C-pulse technique for determining current root growth for some perennial species from the desert indicated that the transition part of roots where root growth continued after exposure to 14C was highly labeled. Old growth contained less ^{14}C than new growth. (Authors) *Keywords:* perennial plants*, life history*, physiology*

787 WALLACE, A., E.F. FROLICH, and G.V. ALEXANDER. 1973. Effect of steam sterilization of soil on two desert plant species. Plant and Soil 39:453-456.

Franseria dumosa Gray and *Hilaria rigida* (Thurb.) Benth. ex Scribn. seedlings were grown in a glasshouse in potted soil which was collected from the Mojave Desert near Mercury, Nevada. The soil represented areas under living shrubs and also areas between shrubs. Soil was either steam sterilized or not steam sterilized. The sterilization resulted in greatly decreased yields of plants possibly because of induced P deficiency. It was suggested that symbiotic mycorrhizae necessary for P absorption for the species involved might have been eliminated by the sterilization. The effect did not hold for a noncalcareous soil well supplied with available P. Soil sterilization increased both Mn and Zn in plants. There was an interaction in that plants did not grow well in soil from under shrubs regardless of steaming indicating possible allelopathic effects. (Authors) *Keywords:* soil property*, microbiota*, perennial plants*, ecology/ecosystem*, nutrition/diet*

788 WALLACE, A., R.T. MUELLER, and E.M. ROMNEY. 1973. Sodium relations in desert plants: 2. Distribution of cations in plant parts of three different species of *Atriplex*. Soil Science 115:390-394.

A. hymenelytra cuttings were grown in Yolo loam soil for 35 days after addition of 3 levels of NaCl (0, 1, 5 g NaCl each applied 3 separate times to 3-kg lots of soil). Plants were not injured by any of the salt treatment. Highest concentrations of Na were in shoots with a steep gradient from top leaves to roots. Cl and K behaved similarly. At the highest salt level, top leaves contained nearly 10% on the dry weight basis of each of Na, Cl and K. Yields of *A. hymenelytra* grown in solution culture responded some to Na and root to leaf gradients for Na and K were similar to the plants grown in soil. Growth of *A. confertifolia* in the presence of a relatively high level of K in solution culture appeared to respond to Na when other nutrients were not limiting. A sharp gradient of Na content existed with leaves higher than stems and stems higher than roots. Yields were also increased by Na for *A. canescens* but Na and K contents were much lower than for *A. confertifolia* and the leaf-stem-root gradient for Na was poorly pronounced. *A. canescens* seemed to be resistant to absorption of large quantities of Na even though it tolerates high levels of it. (NFG) *Keywords:* soil property*, perennial plants*, nutrition/diet*

789 WALLACE, A., W.A. RHOADS, and E.F. FROLICH. 1968. Germination behavior of *Salsola* as influenced by temperature, moisture, depth of planting, and gamma irradiation. Agronomy Journal 60:76-78.

Salsola kali, a troublesome weed, invaded the areas used for above-ground thermonuclear testing at the Nevada Test Site and persisted for a few years thereafter before disappearing from those specific sites. Its germination behavior was studied to clarify its peculiar ecological behavior. Germination and growth of Co-60 y-irradiated seed were examined. Germination was slightly impaired by exposures of seed to doses up to 500,000 R. At 1,000,000 R no seed germinated. Seedlings slowly died when irradiated at =100,000 R. Cell division of germinating seeds was impaired at levels of irradiation much above 50,000 R, and elongation of root and shoot was almost equal above 100,000 R to about 400,000 R. Evidently no new cell division occurs at irradiation levels above about 100,000 R. Apparent seedling growth from such plants would then be from cell elongation only. The embryo, therefore, probably contains the complete seedling with cells all divided and differentiated. Seedlings emerged when the seeds had been covered with 7.5 cm of soil, but not at a depth of 13 cm. The amount of elongation of the seedlings which did not emerge approximated that of seedlings irradiated with Co-60 at levels high enough to stop all new cell division. (BBB) *Keywords:* perturbations*, invasive species*, annual plants*, radiation*

790 WALLACE, A., E.M. ROMNEY, and R.T. ASHCROFT. 1970. Soil temperature effects on growth of seedlings of some shrub species which grow in the transitional area between the Mojave and Great Basin Deserts. BioScience 20:1158-1159.

Thirteen species of shrubs from the Nevada Test Site were subjected to different soil temperatures to investigate the influence of this parameter on growth (as indicated by weights of roots and shoots). Data indicated that soil temperatures are probably an important regulating factor in the growth of different desert shrubs, but the effects are species-specific. The authors postulate that soil temperature is, under many conditions, a primary factor regulating distribution of desert shrubs in western North America. They further speculated that their results are related to photosynthetic pathways: hot desert shrubs being at least partly associated with the C_4-dicarboxylic pathway; cold desert shrubs with the Calvin cycle. (TPO) *Keywords:* soil property*, perennial plants*, life history*, physiology*

791 **WALLACE, A., E.M. ROMNEY, and J.W. CHA. 1980. Depth Distribution of Roots of Some Perennial Plants in the Nevada Test Site Area of the Northern Mojave Desert. Great Basin Naturalist Memoirs 4:201-207.**

The root systems of 48 perennial plants, representing nine species from the Rock Valley area within the northern Mojave Desert, were excavated by 10 cm depth increments to determine, by depth of soil, the distribution of roots larger than about 1/2 mm diameter. The depth of the root zone of all species was relatively shallow and obviously limited by depth of penetration of precipitation (about 10 cm mean annual rainfall). There were species differences, however, in distribution of roots. Even though a sizeable proportion of the root systems was in the first 10 cm of soil, this portion consisted largely of multiple woody tap roots with relatively few small roots. In all cases except one (*Krameria parvifolia* Benth), more small roots were in the second 10 cm than in the first. From 50 to more than 80 percent of the total root systems were in the first 20 cm. In most cases the majority of small roots was found between 10 and 30 cm in depth. Very fine roots were sampled separately by depth and zone without regard for species because they could not be differentiated by species. Relative depth distribution of very fine roots at Rock Valley for 0-10, 10-20, and 20-30 cm, was about 17, 42, and 41 percent, respectively. The total for the first 20 cm was 59 percent. On a 22 April date, there were 225 kg/ha roots from winter annuals in the Rock Valley area; 19 percent of them were in the first 5 cm of soil in contrast to 8 percent in 10 cm of soil for perennials. On Pahute Mesa located in the southern Great Basin desert area of the Nevada Test Site in *Artemisia tridentata* Nutt. var. *tridentata*, 8 percent of the roots was in the first 5 cm, indicating more shallow rooting compared with the northern Mojave Desert. (Authors) *Keywords:* annual plants*, perennial plants*, life history*, ecology/ecosystem*

792 **WALLACE, A., E.M. ROMNEY, and J.W. CHA. 1980. Persistence of ^{14}C Labeled Carbon in *Larrea tridentata* up to 40 Months After Photosynthetic Fixation in the Northern Mojave Desert. Great Basin Naturalist Memoirs 4:172-176.**

Larrea tridentata (Sesse Moc. ex DC) Cov. exposed to $^{14}CO_2$ retained about 20 percent of its ^{14}C after 16 and also after 26 months. In leaves, however, a lower specific activity was present at 26 months than at 16 months, and a smaller percentage of ^{14}C in the plant occurred in leaves at 26 months than at 16 months (3 percent vs 10 percent). This indicates some, but little, reuse of carbon from the structural components of the plants. The strong tendency of the species to retain this carbon may be related to a survival mechanism. After 40 months the results were more erratic, with 11 percent of the ^{14}C remaining in plants and only 2 percent of the total remaining in the leaves. The specific activity of ^{14}C in the organic debris fraction obtained with saturated salt flotation of roots after small and fine roots had been physically removed indicated that from 27 to 35 percent of the organic debris had the same specific activity as roots and probably could be considered as roots. This compares with the 45 percent value determined previously by a different technique. The below-ground to aboveground ratio for biomass of these plants was about 2.5:1. The below-ground to above-ground ratio for the ^{14}C was about 0.5 at 16 months, 1.3 at 26 months, and 2.5 at 40 months. The estimates obtained in this study were used to correct our previous data for belowground biomass. Accordingly, somewhere between 3,000 and 5,000 kg/ha roots are present in the Rock Valley area. An increase with time of the below-ground to aboveground ^{14}C ratio probably indicates loss of ^{14}C from aboveground parts rather than additional transport to roots. (Authors) *Keywords:* perennial plants*, physiology*

793 **WALLACE, A., E.M. ROMNEY, and Collaborators. 1972. Radioecology and Ecophysiology of Desert Plants at the Nevada Test Site. USAEC Report TID-25954, 439 pp.**

The present work has been assembled as a base of future studies regarding radiation effects and radionuclide and mineral cycling problems which are of interest to the Atomic Energy Commission and manipulation experiments such as those of interest to the International Biological Program. This volume also serves as a partial review of literature of topics of importance in meeting the needs of the programs listed. (BBM) Keywords: vegetation*, ecology/ecosystem*, nutrition/diet*, physiology*, radiation*

794 **WALLACE, A., E.M. ROMNEY, and V.Q. HALE. 1973. Sodium relations in desert plants: 1. Cation contents of some plant species from the Mojave and Great Basin Deserts. Soil Science 115:284-287.**

Leaves of 23 plant species native to the Mojave or Great Basin Deserts (USA) were analyzed for mineral cations by an emission spectrographic technique. Some of these species tend to accumulate Na in leaves, particularly species that grow in areas where salts have accumulated. Distribution in the field of 3 *Lycium* species may be related to salinity. Na contents of the *Lycium* species were inversely related to those of Ca. *Grayia spinosa* is an accumulator of large amounts of K in areas where other species accumulate Na. Several members of the Chenopodiaceae accumulated Na in leaves. Plant species and soils both seemed to determine the cation contents of plants. *Larrea divaricata* failed to grow where C horizons were highly saline and where A horizons contained over 10 me/100 g exchangeable K. (EMD) *Keywords:* soil property*, perennial plants*, ecology/ecosystem*, physiology*, nutrition/diet*

795 **WALLACE, A., E.M. ROMNEY, and R.B. HUNTER. 1977. The Challenge of a Desert: Revegetation of Disturbed Lands. In: *Transuranics in Desert Ecosystems*. White, M.G., and P.B. Dunaway (Eds.). NVO-181, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV, pp. 17-40.**

The revegetation of disturbed, arid lands is, indeed, one of the great challenges of a desert. It is not an impossible task, however, if the natural and the man-made resources available are utilized and managed. Where rainfall and temperature conditions approach or exceed those of the Great Basin Desert, restoration of disturbed land will occur through natural revegetation processes within a reasonable period of time. This is not generally the case in the more arid Mohave Desert areas where the moisture and temperature conditions are less favorable for germination and seedling survival. Restoration of vegetation by natural reseeding can, however, occur within local sites where moisture has concentrated as the result of terrain features forming catchment basins. Otherwise, the natural revegetation processes in the Mohave Desert areas require much longer periods of time (possible decades or hundreds of years) than are practical for meeting environmental protection standards. Through better understanding of the processes governing revegetation and the ability to control them, it is possible for man to more rapidly restore disturbed desert lands. Terrain manipulation to form moisture catchment basins, selection of seed from pioneering shrub species, preservation of existing shrub clump "fertile islands" in the soil, supplemental fertilization and irrigation and organic amendments, and transplanting vigorous shrub species are some of the important things that can be done to help restore disturbed desert land. (Authors) *Keywords:* NAEG*, soil property*, perturbations*, vegetation*, revegetation*

796 **WALLACE, A., E.M. ROMNEY, and R.B. HUNTER. 1978. Nitrogen Cycle in the Northern Mojave Desert: Implications and Predictions. Chapter 14, pp. 207-218. In: Nitrogen in Desert Ecosystems. US/IBP Synthesis Series 9, Dowden Hutchinson, and Ross. Stroudsburg, PA.**

The nitrogen cycle in the northern Mohave Desert is characterized by a pool of nitrogen in the soil organic matter fraction from about 500 to 1,500 kg/ha, which is in equilibrium with mineral nitrogen fractions similar to those of other biomes and agricultural systems. The input of nitrogen and losses of nitrogen from the system are very small compared to the size of the soil organic nitrogen pool. Even so, the losses via runoff and leaching are sufficient to result in large accumulations of nitrate in the playas of closed basins common to the Mohave Desert. The amount of annual input is perhaps less than 1 kg/ha per year of newly fixed nitrogen and appears to be almost equally divided between that coming via nitrogenase systems and rainfall deposition. The mineralization process occurs at rates sufficiently high (before or near the time of critical phenological events) to create available nitrogen pools large enough to accommodate, without stress, a wide range of annual primary productivities resulting from differences in annual precipitation. If our conclusions about the relatively small annual inputs of newly fixed nitrogen are correct, then hundreds of years were necessary to obtain the pool sizes observed. We are unable to tell if they are at a steady state at the present time. (Authors) *Keywords:* IBP*, soil property*, microbiota*, vegetation*, nutrition/diet*

797 **WALLACE, A., E.M. ROMNEY, and R.B. HUNTER. 1980. Carbon Fixed in Leaves and Twigs of Field *Larrea tridentata* in Two-Hour Exposure to $^{14}CO_2$. Great Basin Naturalist Memoirs (4):121-123.**

Six *Larrea tridentata* (Sesse & Moc. ex DC) Cov. plants were exposed to $^{14}CO_2$ in a field experiment for 2 h. Three of the plants had been irrigated regularly in the preceding year. Ten small twigs from each plant were removed and counted for ^{14}C activity at the end of 2 h. The stem portion of the twigs was of equal dry weight for the two sets of plants, but those irrigated had a greater weight of leaves per twig. The activity of ^{14}C in leaves was equal for the two groups, but was higher in stems for watered plants than for unwatered plants. The results were best expressed as ratios. Dry weight of leaves ÷ dry weight of stems was high for watered plants; cpm/g dry weight of leaves ÷ cpm/g dry weight of stems was higher for unwatered plants. In another experiment in which leaves were removed before exposing stem portions of twigs to $^{14}CO_2$, small green stems accounted for about 1/8 the total photosynthesis for a plant; the coefficient of variation was around 100 percent. (Authors) *Keywords:* perennial plants*, physiology*

798 WALLACE, A., E.M. ROMNEY, and R.B. HUNTER. 1980. The Challenge of a Desert: Revegetation of Disturbed Desert Lands. Great Basin Naturalist Memoirs (4):216-225.

Where rainfall and temperature conditions approach or exceed those of the Great Basin Desert, restoration of disturbed land will occur through natural revegetation processes within a reasonable period of time. This is not generally the case in the more arid Mojave Desert areas where the moisture and temperature conditions are less favorable for germination and seedling survival. The natural vegetation processes in the Mojave Desert areas require much longer periods of time (possible decades or centuries) than are practical for meeting environmental protection standards imposed by current legislation. Through better understanding of the processes governing revegetation and the ability to control them, it is possible for man to more rapidly restore disturbed desert lands. Terrain manipulations to form moisture catchment basins, selection of seed from pioneering shrub species, preservation of existing shrub clump “fertile islands” in the soil, supplemental fertilization, irrigation, organic amendments, and transplanting vigorous shrub species are some of the important things than can be done to help restore disturbed desert land. (Authors) *Keywords:* climate*, perturbations*, perennial plants*, ecology/ecosystem*, revegetation*

799 WALLACE, A., E.M. ROMNEY, and R.B. HUNTER. 1980. Regulative Effect of Dodder (*Cuscuta nevadensis* Jtn.) on the Northern Mojave Desert. Great Basin Naturalist Memoirs (4):98-99.

On two separate transects in the Rock Valley area of the northern Mojave Desert in the spring of 1976, 4 percent to 17 percent of the perennial plants were infested with the parasite *Cuscuta nevadensis* Jtn. (dodder), and dead pieces of dodder from previous years were on dead plants equivalent to another 5 percent, indicating that the dodder had a regulating effect on the plant population and may be an important cause of perennial plant death. (Authors) *Keywords:* perennial plants*, ecology/ecosystem*

800 WALLACE, A., E.M. ROMNEY, and R.B. HUNTER. 1980. Relationship of Small Washes to the Distribution of *Lycium andersonii* and *Larrea tridentata* at a site in the Northern Mojave Desert. Great Basin Naturalist Memoirs (4):94-97.

At a site near Rock Valley, Nevada, dominated by volcanic rocks, both *Larrea tridentata* (Sesse & Moc. ex DC.) Cov. and *Lycium andersonii* A. Gray were restricted in distribution. *Larrea tridentata* did not grow in the many small washes in the area, but *L. andersonii* grew only in the washes. *Ambrosia dumosa* (A. Gray) Payne was more dense and more dominant in wash areas than in nonwash areas. (Authors) *Keywords:* hydrology*, perennial plants*, ecology/ecosystem*

801 WALLACE, A., E.M. ROMNEY, and R.B. HUNTER. 1982. Effects of washing on mineral composition of leaf samples of *Lycium andersonii*. Soil Science 134(1):31-35.

We collected separately leaves of *Lycium andersonii* A. Gray from 20 different shrubs from the northern Mojave Desert. Half of each sample was washed in 1/10 *N* HCI followed with deionized water before analysis in triplicate by optical emission spectrometry, and the other half was analyzed unwashed. Washed samples contained 12, 35, 33, 40, 55, 47, 57, 8, 9, and 20 percent, respectively, less calcium, zinc, copper, iron, aluminum, silicon, titanium, strontium, barium. lithium, and lead than did unwashed leaves. The losses probably exceed contamination for some elements, because the results differed in some respects from those obtained for citrus. Statistically significant differences were not obtained for other elements analyzed. Even though 40 to 57 percent of the iron, aluminum, silicon, and titanium was washed from the leaves, cluster analyses grouped the four elements into a common cluster whether or not the leaves had been washed. Washing resulted in a lower coefficient of variation for some of the elements compared with unwashed leaves. (Authors) *Keywords:* perennial plants*, nutrition/diet*

802 WALLACE, A., E.M. ROMNEY, and R.B. HUNTER. 1990. Variability and diversity caused by environmental forces in the vegetation at the Nevada Test Site, pp. 209-20. In: Proceedings of the Symposium on Cheatgrass Invasion, Shrub Die-off, and Other Aspects of Shrub Biology and Management. McArthur, E.D., E.M. Romney, S.D. Smith, and P.T Tueller (Eds.),

Las Vegas, NV, April 5-7, 1989. Gen Tech. Rep. INT-276. USDA Forest Service, Ogden, UT.

The northern Mojave Desert in which most of the Nevada Test Site is located has considerable diversity within itself, even within short distances. Differences in land forms terrain, chemical leaching, drainage patterns, and caliche layers are many. Large numbers of shrub species associations exist; in one study site of 46 ha, seven different major plant associations were identified with 20 different groupings of the seven. Valley-to-valley differences in vegetation reflect soil type, drainage pattern, slope, and aspect. North-south gradients are very pronounced in short distances at the Nevada Test Site, and the extreme northern portion is representative of the Great Basin Desert. Rainfall is irregular; the coefficient of variation of annual totals is around 50 percent. That of monthly totals varies from around 100 percent to over 200 percent. Almost more important than total rainfall is timing of rainfall. With a limited number of rain events per year, around 12, the events are not all of equal importance according to prevailing temperatures. There is a rich diversity of plant species in many locations, which results in plants in different pheno phases at a given time. Most species are opportunistic to water, but some are programmed to be dormant at high temperature with relationship to gibberellin production in roots. The northern Mojave Desert has a tight nitrogen cycle, but generally there is sufficient nitrogen to support the growth allowed by the water supply. Because water runs in and runs off, there is differential effect on plants due to nitrogen movement as well as to the water. Small mammals have a tremendous effect upon the vegetation in the Northern Mojave Desert. The plant parasite dodder (*Cuscuta*) also has a regulatory role. (Authors) *Keywords:* climate*, hydrology*, vegetation*, nutrition/diet*, ecology/ecosystem*

803 **WALLACE, A., E.M. ROMNEY, and J.E. KINNEAR. 1980. Frequency Distribution of Three Perennial Plant Species to Nearest Neighbor of the Same Species in the Northern Mojave Desert. Great Basin Naturalist Memoirs 4:89-93.**

Frequency distribution patterns were developed for distance to nearest neighbor of the same species for *Larrea tridentata* (Sesse & Moe. ex DC.) Cov., *Ephedra nevadensis* S. Wats., and *Acamptopappus shockleyi* A. Gray. The distances between shrubs had been determined previously in another study. About one-third or more of the nearest neighbor of its own kind was within less than one meter for each species, indicating that it was usually within the same shrub clump, which in turn is indicative of an aggregating effect. For *L. tridentata* and *E. nevadensis* much of this could be from the same original plant by crown diffusion (*L. tridentata*) or underground spreading (*E. nevadensis*). None of the three gave evidence of spacing at regular intervals when the nearest neighbor of a single individual within a shrub clump was outside that clump. Rather, they appeared to be randomly distributed under this condition, except possibly for *A. shockleyi*. (Authors) *Keywords:* perennial plants*, ecology/ecosystem*

804 **WALLACE, A., E.M. ROMNEY, and R.T. MUELLER. 1969. Effect of the phosphorus level on the micronutrient content of *Franseria dumosa*. Phyton 26:151-154.**

Franseria dumosa plants were grown in solution culture at 4 phosphorus levels and growth and mineral composition were measured. A low level of phosphorus seemed sufficient for maximum yield but phosphorus content at this level was similar to that of other species. A lower level of phosphorus resulted in apparent deficiency without reduced phosphorus content. Micronutrient levels in leaves, notably those of zinc, copper, iron, and manganese, were, however, increased for this treatment. The tendency for high phosphorus levels to induce zinc deficiency can, therefore, perhaps be generalized to include the concept that low phosphorus levels may induce zinc toxicity. (Authors) *Keywords:* perennial plants*, nutrition/diet*

805 **WALLACE, A., E.M. ROMNEY, and R.T. MUELLER. 1976. Nitrogen-Silicon Interaction in Plants Grown in Desert Soil with Nitrogen Deficiency. Agronomy Journal 68:529-530.**

The relationship of N to some other anions was investigated for plants grown in infertile soil low in soil organic matter fertile bare desert areas compared with plants grown in more fertile soil from around natural shrub clumps. The objective was to determine nutrient relationships in the infertility of desert soils even when supplied with N. Range grass [*Hilaria rigida* (Thurb.) Benth. ex Scribn.), barley (*Hordeum vulgare* L. 'Atlas 57'), and bush beans (*Phaseolus vulgaris* L. 'Improved Tendergreen') were grown in such soils in a glasshouse. The latter two were with and without addition of N fertilizer. Plants grown in the infertile soil compared with the fertile soil had greatly decreased yields, were low in N, generally had increased concentrations of Si, and had slightly less total cation concentrations. Nitrogen fertilizer improved yields only slightly in the infertile soil but it increased N concentration and decreased that of Si in plants. The Si seemed to enter into the cation-anion balance in the plants. (Authors) *Keywords:* soil property*, annual plants*, perennial plants*, nutrition/diet*

806 **WALLACE, A., E.M. ROMNEY, and R.A. WOOD. 1973. Cycling of stable cesium in a desert ecosystem. In: (Nelson, D.J., Ed.) *Radionuclides in Ecosystems*, Proceedings of the Third National Symposium on Radioecology (CONF-710501), pp. 183-186.**

Contents of stable cesium and potassium in several compartments of desert ecosystems represented at the Nevada Test Site have been determined by neutron activation, and Cs:K discrimination under natural conditions was evaluated. Stable cesium was circulating but at a low rate. Ratios appeared to narrow going from plants to reptiles and mammals. Stable cesium was freely circulated in desert ecosystems, but at levels lower than that of K by at least 6 orders of magnitude. Stable cesium will influence the cycling of Cs-137. (TPO) *Keywords:* vegetation*, reptile*, mammal*, nutrition/diet*

807 **WALLACE, A., E.M. ROMNEY, and R.A. WOOD. 1982. The role of stable cesium on plant uptake of cesium-137. Soil Science 134(1):71-79.**

Studies were conducted to evaluate the role of stable cesium on plant uptake of cesium-137. Stable Cs applied to soil simultaneously with the ^{137}Cs increased the uptake of ^{137}Cs by bush bean plants by an order of magnitude. Stable Cs applied just after ^{137}Cs had been applied was only half as effective in increasing uptake as was Ca mixed with the ^{137}Cs before application. When bush beans were grown in pots of various sizes, plants in small pots contained much more manganese and less potassium in primary leaves and less ^{137}Cs in all plant parts than did plants grown in large pots. Most Mn was in primary leaves. Three consecutive barley cuttings from the same pots resulted in less ^{137}Cs and Cs in plants from small pots per unit of dry weight than from large pots and in less K, more Ca, and more ^{137}Cs in the third crop. The first crop, besides being lowest in ^{137}Cs, was also lowest in Ca, Mg, P, Mn, Cu, Zn, and Sr relative to the second and third crops. The correlation coefficient between ^{137}Cs and Cs was +0.64, and it was -0.31 between ^{137}Cs and K. (Authors) *Keywords:* annual plants*, nutrition/diet*, radiation*

808 **WALLACE, A., S.A. BAMBERG, J.W. CHA, and E.M. ROMNEY. 1973. Partitioning of photosynthetically fixed ^{14}C in perennial plants of the northern Mohave Desert. IBP Interbiome Symposium. The Belowground Ecosystem: A Synthesis of Plant-Associated Processes, Fort Collins, CO.**

Information concerning the distribution and redistribution of photosynthate among plant parts subsequent to its production is needed to fully understand behavior of vegetation in any ecosystem. The present study was undertaken primarily to obtain information on transport of assimilates into roots of desert vegetation. It was conducted in the northern Mojave Desert where the mean annual rainfall is about 100 mm. Shoots of *Ambrosia dumosa* plants were exposed to $^{14}CO_2$ in 1971 and the distribution of ^{14}C in roots, stems, and leaves measured 1 week, 2 months, and 5 months later. Only about 12% of the photosynthate was stored in the root. Much of that stored in stems was available for new leaf growth. Photosynthate was labeled with ^{14}C for 24 plants representing eight species in 1972. Results showed that after 127 days the mean percentage of ^{14}C in roots as compared with the estimate of that originally fixed was 11.81; the percentage in stems was 43.8. The ratio of root:stem for ^{14}C was 0.212 and only half the ratio for actual weights of field plants. The correlation coefficient for

$$\frac{^{14}\text{C in roots}}{^{4}\text{C in roots + stem}} \quad x \quad \frac{\text{Dry wt of root}}{\text{Dry wt of root + stem}}$$

was +0.89. Small stems were the major storage organs for the ^{14}C. To check the validity of the ^{14}C data, root growth of eight perennial desert plants grown in the glasshouse was followed as plants increased in size. The mean percent of the whole plant that was root for the eight species was 17.7. The mean proportion of the increase in plant weights that went below ground for the eight species was 19.5%. Results of the experiment designed to test the value of the ^{14}C-pulse technique for determining current root growth for some perennial species from the desert indicated that the procedure probably would not be useful for the species involved. (Authors) *Keywords:* IBP*, perennial plants*, life history*, physiology*

809 **WALLACE, A., V.Q. HALE, G.E. KLEINKOPF, and R.C. HUFFAKER. 1971. Carboxydismutase and phosphoenolpyruvate carboxylase activities from leaves of some plant species from the northern Mojave and southern Great Basin Deserts. Ecology 52:1093-1095.**

Of 14 xerophytic plant species studied, only two (members of the Chenopodiaceae) exhibited high phosphoenolpyruvate (PEP) carboxylase and low carboxydismutase activities. Three other members of the Chenopodiaceae exhibited carboxylase activities characteristic of both the C4-dicarboxylic acid pathway and the Calvin cycle in the same species. Activities range from high PEP carboxylase and moderately high carboxydismutase to, conversely, high carboxydismutase and moderately high PEP carboxylase activity, including moderately high levels of nearly equal activities of each enzyme. Hence, gradations between extremes of the two photosynthetic systems can occur in the same species. Members of three other families (Ephedraceae, Zygophyllaceae, and Liliaceae) had carboxylase activities characteristic of both photosynthetic systems in the same species. The enzymatic activity of plants which continue to grow during hot summers was characteristic of either the C_4-dicarboxylic acid pathway or of both photosynthetic pathways. (Authors) *Keywords:* perennial plants*, physiology*

810 **WALLACE, A., R.T. MUELLER, J.W. CHA, and E.M. ROMNEY. 1980. ^{14}C Distribution in Roots Following Photosynthesis of the Label in Perennial Plants in the Northern Mojave Desert. Great Basin Naturalist Memoirs 4:177-191.**

In April and May of 1973, 24 individual plants were exposed to $^{14}CO_2$ with techniques used in our other studies in the field. Seven to 8 months later, part of the plants were excavated and counted by plant part for ^{14}C. The remainder of the plants were excavated at 13 months. The results indicated that from 3 to 20 percent of the carbon for leaves in the next year came from stems and roots of *Grayia spinosa* (Hook) Moq., *Ceratoides lanata* (Pursh) J. T. Howell, *Atriplex confertifolia* (Tory. & Frem.) S. Wats., *Lycium pallidum* Miers, *Ambrosia dumosa* (A. Cray) Payne, and *Acamptopappus shockleyi* A. Cray. Nearly all of the root segments were labeled at sampling time; however, some of the roots were labeled at higher amounts than others, Some roots had very little ^{14}C, and these are assumed to be very new roots rather than dead roots because of their small size. The roots with high levels of ^{14}C are assumed to be formed near the time of labeling, and those with low levels to be formed after the time of labeling. From 17 to 65 percent of the ^{14}C fixed was recovered after 7 to 13 months. (Authors) *Keywords:* perennial plants*, life history*, physiology*

811 **WALLACE, A., E.M. ROMNEY, G.V. ALEXANDER, and J.E. KINNEAR. 1980. Frequency Distribution and Correlation among Mineral Elements in *Lycium andersonii* from the Northern Mojave Desert. Great Basin Naturalist Memoirs 4:146-155.**

Two hundred samples of leaves of *Lycium andersonii* A. Gray, each representing one plant and divided among six different locations, were assayed by emission spectrography. Information for 12 different elements is reported in terms of concentrations, frequency distribution, correlations, and some soil characteristics. The objective was to ascertain the nature of variability for mineral elements within a species. Composition varied significantly for all 12 elements among locations, all within about 20 km. At least part of the variation was due to soil characteristics. Samples from Rock Valley were highest in K, Na, and Li, which effect is associated with volcanic outcrop. Samples from Mercury Valley were highest in P, Mg, Ba, and B. At least Mg is related to the soil composition. Correlation coefficients between element pairs were often very different for all 200 samples versus those obtained for individual locations. Some of the values for all 200 samples together proved to be artifacts. The highest correlation was for Ca X Sr (positive) and next was Ca X Mg (also positive). Most correlations were slightly or strongly positive (24 of 32). Only P X Ca, Ca X Na, Ca X B, and Sr X P seemed to be significantly negative of the 32 correlations examined. Frequency distribution patterns where common populations were grouped were often normally distributed. Li, as previously reported, and Na, Cu, Mn, and B and Ba at some locations were not normally distributed. Wide variations in the concentrations of individual elements in leaves of these species were encountered. (Authors) *Keywords:* perennial plants*, nutrition/diet*

812 **WALLACE, A., E.M. ROMNEY, J.W. CHA, and G.V. ALEXANDER. 1974. Sodium relations in desert plants: 3. Cation-anion relationships in three species which accumulate high levels of cations in leaves. Soil Science 118:397-401.**

Three desert perennial plant species (*Lycium andersonii* Gray, *Atriplex confertifolia* (Torr. & Frem.) Wats., and *Atriplex hymenelytra* (Torn) Wats. were grown in soil in a glasshouse with different sources of Na (N03, C1-, H2P04) to evaluate their effects upon cation-anion balance in the plants. Each anion greatly increased leaf content of itself with only minor if any interactions with other anions. The milliequivalent sum of anions measured (N, P, C1), therefore, increased in each plant part with the soil applications. Simultaneously there were usually modest increases in the milliequivalent sum of cations. The cation-anion ratio was decreased markedly when NaN03 was added. The ratio was usually over one which means that considerable bicarbonate absorption and organic acid synthesis must occur in all three species. Maximum content of Cl and N in leaves was with *L. andersonii*, 13.51, and 6.37 percent, respectively, when each was added. There were some compensations among other cations as Na was increased so that a somewhat constant sum of cations was maintained although there were significant differences. *L andersonii* appeared to be an accumulator of Li and

A. hymenelytra of Cd. (Authors) *Keywords:* soil property*, perennial plants*, physiology*, nutrition/diet*

813 **WALLACE, A., E.M. ROMNEY, J.W. CHA, and S.M. SOUFI. 1974. Nitrogen transformations in Rock Valley and adjacent areas of the Mohave Desert. US/IBP Desert Biome Res. Memo. 74-36. Utah State University, Logan, 25 pp.**

This progress report discusses some aspects of nitrogen cycling and nitrogen transformations in the northern Mohave Desert with special attention to the Desert Biome Validation Site at Rock Valley. Since the study has been in effect less than a year, critical information regarding the objectives is still incomplete. Preliminary studies indicate much of interest. The acetylene reduction test for nitrogenase has indicated that the rhizosphere of several species of desert plants has some capacity for atmospheric nitrogen fixation and may be sufficient to supply an important part of the needs of a desert system. Soil from the desert had a significant capacity for nitrogen fixation provided an energy source was supplied. Algae was significant in that light resulted in considerably more fixation than did dark. The nitrogen concentration of leaves of many desert plant species is exceptionally high and one of the suspected reasons is a semisymbiotic or a symbiotic nitrogen-fixing relationship. The uptake of nitrate and ammonium nitrogen by several species of desert plants has been followed in solution cultures in the laboratory. Differences were noted, but in general both forms were readily available to the species. The C/N ratios in Rock Valley soils appear to be normal, but in some of the adjacent areas they are somewhat low. Reasons for this must be elucidated, but there are indications of little volatilization or denitrification losses. Nitrogen analyses of roots and shoots by season indicate possible uptake of N by some species during the dormant season and other changes related to phenological events. Some 25 to 80% of the nitrogen in leaves of most of the species seems to be returned to the plant before leaf abscission. The large flooding loss of nitrogen from the desert bajadas has resulted in considerable nitrate accumulation in profiles in areas at lower elevation. This phenomenon has considerable implications. Efforts will be continued towards accomplishment of the original objectives. (Authors) *Keywords:* IBP*, soil property*, microbiota*, perennial plants*, nutrition/diet*

814 **WALLACE, A., E.M. ROMNEY, G.E. KLEINKOPF, and S.M. SOUFI. 1978. Uptake of mineral forms of nitrogen by desert plants. Chapter 9, pages 130-151. In: Nitrogen in Desert Ecosystems. US/IBP Synthesis Series 9. Dowden, Hutchinson & Ross, Inc., Stroudsburg, PA.**

Nitrogen uptake and assimilation by plants are key steps in nitrogen cycling in any ecosystem. Under desert conditions, information is lacking in most areas related to these problems. The forms and amounts of nitrogen which are available on a seasonal basis have not been satisfactorily documented. Nitrate concentrations are obviously low, but they are seasonally high enough to meet much, if not most, of the short-term plant need for nitrogen. Desert plants commonly respond to addition of nitrogen fertilizer, especially when additional soil moisture is added. Mass flow of salts in water moved to the root could bring substantial quantities of nitrate to root surfaces even though the concentration in soils at any one time is low. Nitrogen recycling within the plant is a conservation measure which decreases need for new supplies of nitrogen from the external medium. The two processes just mentioned perhaps are most important in meeting the nitrogen needs of desert plants. The presence of nitrate in the leaves of some plant species implies that they absorb nitrate. Since nitrate reductase is an induced enzyme, its presence in field-grown plants also implies that nitrate is being utilized. There is more to be learned about the status and implication of nitrate reductase concentrations in desert plants. Ammonium and nitrate uptake have been studied for several species of desert plants under glasshouse conditions. The two forms of nitrogen can be taken up and assimilated with equal facility. In some cases, however, there seemed to be a lag in the rate of nitrate uptake since the ratio of nitrate: ammonium uptake increased with time. No critical studies have yet been made of the kinetics of nitrogen uptake by desert plants to indicate the degree of affinity which such plants might have for particular ionic forms of nitrogen. The ionic balance in some field-grown desert plants for which cation-anion values were estimated implies that nitrate is a major form of nitrogen taken up by desert plants. A steady state of nitrogen input and outgo in desert ecosystems may involve relatively small annual rates of each, with a sufficiently large pool of soil organic N which can buffer against high usage or high loss years. (Authors) *Keywords:* IBP*, soil property*, perennial plants*, nutrition/diet*

815 **WALLACE, A., E.M. ROMNEY, H. NISHITA, and D.J. HERMAN. 1980. Studies to Measure Ability of Deep-Rooted Plants to Take up Plutonium and Americium from Deep Portions of Soil. DOE/SF-00012-0T12, CIC 0083225, University of California, Los Angeles, 6 pp.**

Studies have been under way for almost two years to further ascertain ability of deep rooted plants to take up radionuclides (R. K. Schulz has some data for fission products). Transuranic elements were of interest in this study. Those studies have relevance to shallow land disposal of radionuclides because of past burial practices at different locations. This experiment serves to both measure uptake but also to demonstrate the ability of roots to easily penetrate ten feet of soil which is deeper than the top of some shallow land burial trenches. The experiment is in progress and as yet none of the analytical data are available. Six clear plastic columns 300 cm. in height (about 10 feet) by 10 am. I.D. were used. Alfalfa was selected because of its fast growth, deep roots, and tolerance to continued cropping. Each spike, which formed a 27 cm. band of soil within each column, consisted of Pu (7.4 x 10^3 d/s/gram soil) and Am (7.1 x 10^2 d/s/grams soil), in 3 mg. soil. The spikes were included in the six columns at 3 different depths (2 reps each) at 80, 160 or 253 cm. to top of band from top of column. The experiment was planted to alfalfa on June 19, 1978 and harvested as it reached half-bloom stage or when lodging started. This resulted in approximately monthly harvests. Water was supplied on demand so as not to over-water and to encourage roots to grow deep. Root growth in the six columns was very uneven, however. (Authors) *Keywords:* perennial plants*, nutrition/diet*, radiation*

816 **WALLACE, A., A.T. VOLLMER, R.T. MUELLER, and J.W. CHA. 1979. Plant Productivity and Nutrient Interrelationships of Perennials in the Mohave Desert. US/IBP Desert Biome Res. Memo. 77-7. Utah State University, Logan, 10 pp.**

Various studies of aspects of perennial plant productivity, most of which relate to carbon budget of the northern Mohave Desert, were continued in 1976. *Larrea tridentata* exposed to $^{14}CO_2$ in photosynthesis 26 months previously still retained about 20% of its ^{14}C and this was also the retention level at 16 months. However, lower specific activity was present in leaves at 26 months than at 16 months. A smaller percentage of ^{14}C in the plant also occurred in leaves at 26 months than at 16 months (3% vs. 10%). This indicates some, but little, reuse of carbon from the structural components of the plants. The strong tendency of the species to retain this carbon by conservation may be related to a survival mechanism. The specific activity of ^{14}C in the organic debris fraction from saturated salt flotation of roots after small and fine roots had been removed indicated that from 27 to 35% of the organic debris had the same specific activity as roots and could probably be considered as roots. This compares with the 45% value determined previously by a different technique. The below-ground: above-ground ratio for biomass of these plants was about 2.5:1. The ratio for the ^{14}C was about 1.4:1. The data obtained in this study were further used to correct our previous data for below-ground biomass. Somewhere between 3000 and 5000 kg roots/ha are present in the Rock Valley area. An increase with time of the below-ground:above-ground ^{14}C ratio probably indicates loss of ^{14}C from above-ground parts rather than additional transport to roots. Depth distribution of very fine roots at Rock Valley for 0-10, 10-20 and 20-30 cm were about 17, 42 and 41%, respectively. On April 22, there were 255 kg roots/ha from winter annuals in the Rock Valley area; 19% of them were in the first 5 cm of soil in contrast to 8% for 10 cm of soil for perennials. On Pahute Mesa of the Nevada Test Site in *Artemisia tridentata*, 8% of the roots were in the first 5 cm, indicating shallower rooting compared with the northern Mohave Desert. In a 12-week study of *Ambrosia dumosa*, in solution culture so that root behavior could be observed, plants increased in size over 17 times and flowered and produced seeds. The plants had received $^{14}CO_2$ in photosynthesis at the start. The gradual loss of ^{14}C in the 12 weeks averaged 3.5% per week (coefficient of variation = 58%). This represents an average respiration rate of 0.21 mg·C·g dry $wt^{-1} \cdot hr^{-1}$. This compares favorably with other means for determination of respiration rate. The root portion of the plant, both as biomass and ^{14}C, varied little over the six sampling periods. The ^{14}C entering fruits and seeds came from leaves only, but fruit parts resulted more from new photosynthate than from retranslocation from leaves. In a study in which A. dumosa plants were defoliated, little ^{14}C moved from roots to new growth, as implied in the other study. The respiration rates found for desert soils were much lower than those from areas receiving high soil moisture. From 0 to about 5% of stems of different shrub species died in the year of study. Flower-bud removal from *Larrea tridentata* had no effect on growth characteristics of the shrubs in the year of study. (Authors) *Keywords:* IBP*, perennial plants*, physiology*, ecology/ecosystem*

817 **WALLACE, A., E.M. ROMNEY, R.B. HUNTER, J.E. KINNEAR, and G.V. ALEXANDER. 1980. Mineral Composition of *Atriplex hymenelytra* Growing in the Northern Mojave Desert. Great Basin Naturalist Memoirs 4:156-162.**

Fifty samples of *Atriplex hymenelytra* (Torn) S. Wats. were collected from several different locations in southern Nevada and California to test variability in mineral composition. Only Na, V, P, Ca, Mg, Mn, and Sr in the samples appeared to represent a uniform population resulting in normal curves for frequency distribution. Even so, about 40 percent of the variance for these elements was due to location. All elements differed enough with location so that no element really represented a uniform population. The coefficient of variation for most elements was over 40 percent and one was over 100 percent. The proportion of variance due to analytical variation averaged 16.2 f 13.1 percent (standard deviation), that due to location was 43.0 f 13.4 percent, and that due to variation of plants within location was 40.7 f 13.0 percent. (Authors) *Keywords*: perennial plants*, nutrition/diet*

818 **WALLACE, A., E.M. ROMNEY, R.A. WOOD, A.A. EL-GHONEMY, and S.A. BAMBERG. 1980. Parent Material Which Produces Saline Outcrops as a Factor in Differential Distribution of Perennial Plants in the Northern Mojave Desert.**

Great Basin Naturalist Memoirs 4:140-145.

An area of 0.46 km^2 divided into six zones in the northern Mojave Desert transitional with the Great Basin Desert has been studied. Diversity is high among the perennial plant species within the 0.46 km^2 area. Common species for the two deserts that are present in the area studied are *Atriplex confertifolia* (Torn & Frem.) S. Wats., *Ceratoides lanata* (Pursh) J. T. Howell, *Grayia spinosa* (Hook.) Moq., *Ephedra nevadensis* S. Wats. Some other species present include *Lycium andersonii* A. Gray, *Lycium pallidum* Miers, *Ambrosia dumosa* (A. Gray) Payne., *Larrea tridentata* (Sesse & Moc. ex DC) Cov., *Acamptopappus shockleyi* A. Gray, and *Krameria parvifolia*, Benth. Some of the species are relatively salt tolerant and some are relatively salt sensitive. A total of 4282 individual plants were measured. There was considerable variation in distribution of the 10 dominant species present, apparently due to zonal variations of salinity dispersed within the study area. Correlation coefficients among pairs of the species for different zones illustrate interrelationships among the salt-tolerant and salt-sensitive species. Observations on an adjacent hillside with rock outcroppings indicate that the saline differences in this area are partly due to outcroppings of parent volcanic rock materials that yield Na salts upon weathering. (Authors) *Keywords:* soil property*, perennial plants*, ecology/ecosystem*

819 WALLACE, G.A., and A. WALLACE. 1990. Using Polymers to Enhance Shrub Transplant Survival and Seed Germination for Revegetation of Desert Lands. In: Proceedings of the Symposium on Cheatgrass Invasion, Shrub Dieoff, and Other Aspects of Shrub Biology and Management. McArthur, E.D., E.M. Romney, S.D. Smith, and P.T Tueller (Eds.), Las Vegas, NV, April 5-7, 1989. Gen Tech. Rep. INT-276. USDA Forest Service, Ogden, UT.

Polymer soil conditioners can be useful for several different purposes in the management of arid lands. Among these is the very inexpensive procedure of applying water-soluble polymers in solution into transplant holes when trees and shrubs are transplanted. The procedure allows for the addition of water without destroying any soil structure. Some gypsum is used with the polymer. Good soil aeration results, and there is no soil interface problem. Another use is a combination of water-soluble and gel polymers, which are predissolved and swollen so that some of the slurry (200 mL to 2,000 mL or more) can be added to a small depression, seeds are applied on top, and then the seeds are covered with as much soil as desired. The polymer mixture supplies water for the germinating seeds and is well aerated. The water is released slowly, is not rapidly dissipated into hot, dry soil, and the liner polymer prevents adjacent soil from crusting. The procedure can enhance seed germination and survival in areas with very low rainfall. (Authors) *Keywords:* hydrology*, soil property*, perennial plants*, revegetation*

820 WASBAUER, M.S. 1973. The male brachycistidine wasps of the Nevada Test Site (Hymenoptera: Tiphiidae). Great Basin Naturalist Memoirs 33:109-112.

Wasps of genera *Acanthetropis, Brachycistis, Brachycistina, Colocistis* and *Quemaya* were identified from 111 specimens collected from the Nevada Test Site, USA. (JJB) *Keywords:* invertebrate*, taxonomy*

821 WEBB, R.H., and E.B. NEWMAN. 1982. Recovery of soil and vegetation in ghost-towns in the Mojave Desert, southwestern United States. Environmental Conservation 9(3):245-248.

As part of a US Geological Survey project to study the recovery rates of soils and vegetation in environments, six ghost-towns are being examined in the northern Mojave Desert of California and Nevada, USA. These are Wahmonie, in Nye County, Nevada [*on the NTS*]; Skidoo, in the Panamint Mountains of Death Valley National Monument, Inyo County, California; and Greenwater, Furnace, Kunze, and Gold Valley, in the Black Mountains of Death Valley National Monument, Inyo County, California. A leading objective of this study is to provide baseline information for continued land-use planning in the desert. (Authors) *Keywords:* soil property*, perturbations*, vegetation*, revegetation*

822 WEBB, R.H., and H.G. WILSHIRE. 1980. Recovery of Soils and Vegetation in a Mojave Desert Ghost Town, Nevada, U.S.A. Journal of Arid Environments 3:291-303.

Recovery rates of vegetation and compacted soil were studied at the Wahmonie ghost town in southwestern Nevada [*on the NTS*]. Soil in the town site has not completely recovered from compaction in the 51 years since the site was abandoned; recovery trends indicate a recovery time on the order of a century. The composition of vegetation in the town site consists of short-lived perennials whereas the surrounding undisturbed vegetation consists mainly of long-lived perennials. Comparison of the vegetation recovery in the town site with recovery in little-used streets shows that soil compaction is a major limiting factor on the revegetation of disturbed desert areas; the recovery rate of vegetation in compacted soil is too low to allow prediction of a full-recovery time. (Authors) *Keywords:* soil property*, perturbations*, vegetation*, revegetation*

823 WEBB, R.H., J.W. STEIGER, and H.G. WILSHIRE. 1986. Recovery of compacted soils in Mojave Desert ghost towns. Journal of the Soil Science Society of America Journal 50:1341-4.

Residual compaction of soils was measured at seven sites in five Mojave Desert ghost towns. Soils in these Death Valley National Monument townsites were compacted by vehicles, animals, and human trampling, and the townsites had been completely abandoned and the buildings removed for 64 to 75 yr. The soils studied (generally sandy, mixed, Typic Calciorthids) were derived from granitic or volcanic alluvium at elevations from 1,310 to 1,730 m. Compaction measurements in the townsites, including penetration depth, penetration resistance, bulk density, and peak shear stress, indicated that only one site had completely recovered to ambient soil conditions after 75 yr. Recovery times extrapolated using a linear recovery model ranged from 80 to 140 yr and averaged 100 yr. The recovery times were related to elevation, suggesting freeze-thaw loosening as an important factor in ameliorating soil compaction in the Mojave Desert. (Authors) *Keywords:* soil property*, perturbations*

824 WELLS, C., D. PATAKI, D. SCHORRAN, W. CHENG, and R. NOWAK. 2000. A system for soil CO_2 flux measurements at the Nevada Desert FACE Facility. FACE 2000 Conference, June 27-30, 2000, Tsukuba, Japan.

A continuous, open-flow gas exchange system has been constructed to measure soil CO_2 flux from bare, undisturbed soil in three ambient (350 PPM CO_2) and three elevated (550 PPM CO_2) rings at the Nevada Desert FACE Facility (NDFF). CO_2 concentrations inside and outside of 18 soil respiration cuvettes (three cuvettes per ring) are measured and used to calculate CO_2 flux at six-minute intervals. The system incorporates mixing chambers and line delays designed to minimize the effects of marked fluctuations in atmospheric CO_2 which occur at fine temporal and spatial scales in elevated rings due to CO_2 efflux from individual risers. CO_2 flux from the dry, alkaline soil of the NDFF is relatively low compared to that of other ecosystems and exhibits a strong diurnal pattern characterized by negative nighttime flux. During the period of early spring rainfall in 2000, daily net CO_2 flux ranged from -0.53 mmol CO_2 $m^{-2}d^{-1}$ to 21.97 mmol CO_2 $m^{-2}d^{-1}$ and was strongly influenced by temperature and precipitation. Although there was a trend towards greater daily CO_2 loss in elevated rings (5.12 ± 4.27 mmol CO_2 $m^{-2}d^{-1}$ elevated, 4.55 ± 4.62 mmol CO_2 $m^{-2}d^{-1}$ ambient), this difference was not significant ($P < 0.254$, Student's *t*-test). The NDFF soil respiration system is currently being expanded to include measurements beneath shrub canopies in order to assess the impact of elevated CO_2 on root respiration and the respiration of root-derived organic material. (Authors) *Keywords:* FACE*, soil property*, perennial plants*, physiology*, methods

825 WELLS, P.V. 1961. Succession in Desert Vegetation on Streets of a Nevada Ghost Town. Science (134):670-671.

Vegetation was sampled on the old street system of Wahmonie, Nevada, and on a less disturbed area immediately adjacent. The vegetation on the denuded upland site showed a large increase in bunch-grass and an invasion by pioneer shrubs which ordinarily are chiefly confined to dry washes. (Author) *Keywords:* perturbations*, vegetation*, ecology/ecosystem*

826 WELLS, P.V., and C.D. JORGENSEN. 1964. Pleistocene wood rat middens and climatic change in Mohave Desert: a record of juniper woodlands. Science 143:1171-1174.

Leafy twigs and seeds of juniper are abundant in nine ancient *Neotoma* middens discovered in low, arid, desert ranges devoid of junipers, near Frenchman Flat, Nevada. Existing vegetation is creosote bush and other desert shrubs. Twelve radiocarbon dates suggest that the middens were deposited between 7,800 to more than 40,000 years ago. Dominance of Utah juniper and absence of pinyon pine in most deposits indicates a local Pleistocene woodland climate more arid than the usual pinyon-juniper climate. (Authors) *Keywords:* climate*, vegetation*, perennial plants*, mammal*, ecology/ecosystem*

827 WELLS, P.V., and L.M. SHIELDS. 1964. Distribution of *Larrea divaricata* in relation to a temperature inversion at Yucca Flat, southern Nevada. Southwestern Nat. 9:51-55.

Larrea divaricata Cav. is at a northern limit of its range in Yucca Flat, and occurs here in local aggregations chiefly on the middle slopes of the basin. Measurement of temperature along a gradient of elevation during a 7-month period from

December to July recorded the repeated presence of a nocturnal temperature inversion due to cold air drainage into the basin. Larrea is essentially lacking in the cold-air "lake," but also fails to occupy completely some sectors of the gradient

where the temperature regime appears to be favorable. (Authors) *Keywords:* climate*, perennial plants*, ecology/ecosystem*

828 WESSMAN, R.A., M. BENZ, and L. LEVENTHAL. 1976. Procedures for the Analysis of NAEG Small Vertebrate Samples. In: *Nevada Applied Ecology Group Procedures Handbook for Environmental Transuranics*. White, M.G., and P.B. Dunaway (Eds.). NVO-166, U.S. Energy Research and Development Administration, Nevada Operations Office, Las Vegas, NV, pp. 315-323.

The methodology used in the analysis of NAEG vertebrate samples is described for the transuranic isotopes $^{239\text{-}240}$Pu, ^{241}Am, the fission product isotope ^{90}Sr, and the neutron activation produced isotope ^{55}Fe. The methodology is similar to that used for the analysis of NAEG large vegetation samples (Ref. 1) and NAEG large-sized bovine samples (Ref. 2). The analytical procedures are summarized and more detailed procedural steps are included at the end of the summary. (Authors) *Keywords:* NAEG*, vertebrate*, radiation*, methods*

829 WHITE, L.D. 1962. Concrete molds of rodent burrows. Journal of Mammalogy 43:265.

A grout mixture was used to help define the underground burrow systems of kangaroo rats, *Dipodomys merriami* and *D. microps*, on the Nevada Test Site. Mix ratios were determined empirically: in dry, loosely packed soils more water was needed to allow for loss to the soil. Grout hardened sufficiently in about one week and burrows could be excavated without losing the pattern of the burrow due to crumbling earth. (TPO) *Keywords:* mammal*, ecology/ecosystem*, methods*

830 WHITE, L.D., and D.M. ALLRED. 1961. Range of kangaroo rats in areas affected by atomic detonations. Proceedings: Utah Academy of Sciences, Arts and Letters 38:101-110.

Studies of the range of movement for kangaroo rats were conducted in plant communities both disturbed and undisturbed by the nuclear tests conducted at the Nevada Test Site. Seven hundred and ninety rats were captured, marked, and recaptured. Findings indicated that animals living in areas disturbed by atomic detonations ranged almost three times as far as animals living in the undisturbed areas. Most of the animals of each of the two species studied ranged between 75 ft and 300 ft. The greatest distance recorded for *Dipodomys merriami* was 10,296 ft, and for *D. microps*, 5,280 ft. Ranges for *D. merriami* varied from 0.90 acres to 6.53 acres, and those of *D. microps* from 0.69 acres to 7.80 acres. (BBM) *Keywords:* perturbations*, mammal*, ecology/ecosystem*

831 WHITE, M.G., and P.B. DUNAWAY (Eds.). 1975. *The Radioecology of Plutonium and Other Transuranics in Desert Environments*, Nevada Applied Ecology Group Progress Report as of January 1975. NVO-153, 504 pp.

This document provides a status report of the Nevada Applied Ecology Group (NAEG) whose mission is to determine the distribution and amounts of transuranics in the environment of the Nevada Test Site. Summaries of 21 studies are provided in 10 chapters that include: Distribution and Inventory; Resuspension; Soils; Microorganisms; Vegetation; Small Vertebrates; Large Vertebrates; Statistics; Decontamination Procedures; and Support Activities. Significant progress has been made in describing the distribution of plutonium and other radionuclides for NTS safety-shot areas, but results of inventory efforts for the entire NTS have been modest. Concentrations within components of the desert ecosystem are described and should provide useful quantification for modeling efforts that are also progressing well. A satisfactory evaluation of the radiological hazards of plutonium on NTS has not been formulated, which necessarily limited efforts to identify areas for possible cleanup. Existing decontamination techniques are being evaluated for possible application on NTS. Future efforts will be directed towards initiating experimental cleanup and treatment trials, studies of nuclear event sites containing plutonium, and completion of the inventory and distribution measurements for all contaminated areas on the NTS. (TPO) *Keywords:* NAEG*, radionuclide inventory*, microbiota*, vegetation*, vertebrate*, nutrition/diet*, ecology/ecosystem*, radiation*, revegetation*, methods*

832 WHITE, M.G., and P.B. DUNAWAY (Eds.). 1976. Studies of Environmental Plutonium and Other Transuranics in Desert Ecosystems. NVO-159. U.S. Energy Research & Development Administration, Nevada Operations Office, Las Vegas, NV.

This NAEG publication is the result of a workshop held in Las Vegas on May 6-7, 1975. This document is comprised of summary progress reports of investigators and support activities of the NAEG, Nevada Operations, Office. Funded by the Division of Military Application, Headquarters, ERDA. The NAEG investigators have provided an update of various environmental studies currently in progress at the Nevada Test Site. The investigations are part of an integrated research program, designed: to provide information on the movement of plutonium and other radionuclides in the environment of NTS; to predict any possible associated hazard to man; and to recommend related cleanup and treatment, if required, for radioactively contaminated areas. Research areas focus on soils, vegetation, large and small vertebrates, microorganisms, distribution and inventory, resuspension, and statistics. (Authors/WKO) *Keywords:* NAEG*, radionuclide inventory*, microbiota*, vegetation*, vertebrate*, nutrition/diet*, ecology/ecosystem*, radiation*, methods*

833 WHITE, M.G., and P.B. DUNAWAY (Eds). 1977. Transuranics in Natural Environments. NVO-178. Nevada Applied Ecology Group, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV.

Perhaps the most important step in any organized scientific effort is the periodic review and evaluation of the known and the unknown aspects of a problem. Identification and acknowledgment of relationships and consideration of alternative courses of investigation are extremely important steps in attempt to reach solutions to a problem; or, at best, to gain information and guidance for moving out into the unknown. The Nevada Applied Ecology Group Symposium on the Dynamics of Transuranics in Terrestrial and Aquatic Environments was held in October, 1976, at Gatlinburg, Tennessee. The symposium was planned to bring about a concerted review and evaluation of the current status of a major environmental problem and the associated body of information available to investigators involved in studies of environmental transuranics. Papers selected for publication in this document are coauthored by scientists and other technical and professional people from several national laboratories, academic institutions, private corporations, and government agencies. It is recognized that not all aspects of environmental transuranics are covered in this publication. Reports by M. Wahlgren, Argonne National Laboratory (read by J. Alberts, ANL), and J. Pinder, Savannah River Ecology Laboratory, were not received for publication, and a report by A. L. Boni and R. W. Taylor, SRL, E.I. DuPont, "Plutonium Isotope Distribution in U.S. Surface Waters," was not cleared for publication. It is hoped that those areas of environmental transuranics research not presented in this document will be included in publications currently underway or planned by other research groups. An addition to environmental transuranics literature since the Gatlinburg symposium was the two-volume *Nevada Applied Ecology Group Procedures Handbook for Environmental Transuranics, NVO-166.* The NAEG procedures handbook (dated October, 1976, released in May, 1977) includes most of the NAEG standard procedures used in applied environmental plutonium and other transuranics sampling at the Nevada Test Site, with related laboratory and statistical procedures. The handbook is available from the National Technical Information Services, NTIS, Springfield, Virginia. (Authors) *Keywords:* NAEG*, radionuclide inventory*, microbiota*, vegetation*, vertebrate*, nutrition/diet*, radiation*, methods*

834 WHITE, M.G., and P.B. DUNAWAY (Eds). 1978. Selected Environmental Plutonium Research Reports of the NAEG. NVO-192. Nevada Applied Ecology Group, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV.

On February 28 through March 2, 1978, the Annual Plutonium Information Conference was held in San Diego by the Nevada Applied Ecology Group. Many presentations by the NAEG research groups were summarizing reports. A few discussed progress to date on certain projects. And, the third day of the conference was set aside for contributed papers, mostly from institutions other than NAEG-contracted organizations. This publication, printed in two volumes, is of the proceedings of the conference, perhaps the best meeting ever held by the NAEG. (Authors) *Keywords:* NAEG*, radionuclide inventory*, microbiota*, vegetation*, vertebrate*, nutrition/diet*, ecology/ecosystem*, radiation*, methods*

835 WHITE, M.G., and H.A. PFUDERER (Compilers). 1978. Nevada Applied Ecology Group Publications. NVO/AEIC-78/1, Nevada Applied Ecology Information Center, Oak Ridge National Laboratory, 176 pp.

This bibliography serves as a guide to the environmental studies sponsored by the Nevada Applied Ecology Group (NAEG) at the Department of Energy Nevada Test Site nuclear weapons complex. The NAEG is part of the Nevada Operations Office of the United States Department of Energy. The references included in the bibliography reflect the interests of the NAEG (e.g., hazard evaluation of the nuclear safety-shot sites). The objectives of the NAEG plutonium studies at the Nevada Test Site were defined as follows: (1) delineate locations of contamination; (2) determine concentrations in ecosystem components; (3) quantify rates of movements among ecosystem components; (techniques for cleanup or treatment. (Authors) *Keywords:* NAEG*, bibliography*

836 WHITE, M.G., P.B. DUNAWAY, and W.A. HOWARD (Eds.). 1977. Environmental Plutonium on the Nevada Test Site and Environs. NVO-171. Nevada Applied Ecology Group, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV.

The Nevada Applied Ecology Group (NAEG) annual information conference held in Las Vegas, Nevada, in February, 1976, resulted in some interesting reports. This publication is a compilation of research reports presented at that meeting, as well as those presentations concerning support to the group field studies at the Nevada Test Site. The objectives of the NAEG are restated here: (1) Delineate locations of contamination, (2) Determine concentrations in ecosystem components, (3) Quantify rates of movement among ecosystem components, (4) Evaluate radiological hazards of plutonium, (5) Identify areas which need to be cleaned up or treated, and (6) Develop techniques for cleanup or treatment. Work in the NAEG safety-shot intensive study sites is nearing final stages; the planning for NAEG studies in the nuclear event sites at the Nevada Test Site is progressing to an early field operations beginning. Synthesis and evaluation of the data generated during the 3 years of safety-shot plutonium studies has been accelerated in recent months so as to provide guidance for the nuclear site projects. Several authors of papers in this publication have made efforts at synthesis of data under their respective investigative responsibility. (Authors) *Keywords:* NAEG*, radionuclide inventory*, microbiota*, vegetation*, vertebrate*, nutrition/diet*, physiology*, radiation*, methods*, revegetation*

837 WHITE, M.G., P.B. DUNAWAY, and D.L. WIREMAN (Eds.). 1977. Transuranics in Desert Ecosystems. NVO-181. Nevada Applied Ecology Group, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV.

The Annual Plutonium Information Conference of the Nevada Applied Ecology Group (NAEG) was held in March, 1977, in Las Vegas. This document contains the research reports presented at the conference. The initial activities of the environmental transuranics studies planned by the NAEG are underway. Some of the presentations at this conference included safety-shot study findings, and attempts to synthesize the ten NAEG safety-shot study areas in desert environments. Other reports include refinement of estimates of inventory in surface soil on safety-shot sites. (Authors) *Keywords:* NAEG*, radionuclide inventory*, vegetation*, vertebrate*, nutrition/diet*, radiation*, methods*

838 WIELAND, P.A.T., E.F. FROLICH, and A. WALLACE. 1971. Vegetative propagation of woody shrub species from the northern Mojave and southern Great Basin Deserts. Madrono 21:149-152.

Stem cuttings of 16 desert (USA) perennial shrub species were successfully rooted although juvenile material was needed in many cases. At least one of these (*Larrea divaricata* [Cav.]) is a species for which earlier attempts to root had been unsuccessful. Conditions for successful rooting varied with species. *L. divaricata, Atriplex hymenelytra* (Tory.) Wats., *Atriplex confertifotia* (Torn. and Frem.) Wats., and *Coleogyne ramosissima* Torr. rooted more readily in soil than in vermiculite. IBA was not needed for *Atriplex* species (all *Atriplex* rooted) nor for *Kochia americana* Wats. *L. divaricata, Lycium andersonii* Gray, *Lycium pallidum* Miers, Lycium shockleyi Gray, *Franseria dumosa* Gray, *Artemisia tridentata* Nutt. and *Grayia spinosa* (Hook) Moq. required mist or responded satisfactorily to mist rooting while other species disintegrated rapidly under the same circumstances. Other species rooted equally or better under dry conditions or even in a lathhouse where temperatures were lower. These include *G. spinosa*, *Eurotia lanata* (Pursh) Moq., *Ephedra viridis* Cov., and *Thamnosma montana* Torr. and Frem. *Ephedra viridis* responded to bottom heat. The species studied for which stem cuttings have failed to root include *Krameria parvifolia* Benth. and *Juniperus osteosperma* (Tory.) Little. (HR) *Keywords:* perennial plants*, life history*, ecology/ecosystem*, revegetation*

839 WILDUNG, R.E., H. DRUCKER, and F.H.F. AU. 1977. The Relationship of Microbial Processes to the Fate of Transuranic Elements in Soil. In: *Transuranics in Natural Environments*. White, M.G., and P.B. Dunaway (Eds.). NVO-178, Nevada Applied Ecology Group, U.S. Energy Research & Development Administration, Las Vegas, NV, pp. 127-169.

This review considers the influence of soil physiochemical and microbial processes on the long-term solubility, form, and plant availability of plutonium and other transuranic elements important in the nuclear fuel cycle. Emphasis is placed on delineation of the relationships between soil chemical and microbial processes and the role of soil microorganisms in effecting solubilization and transformation of elements considered largely insoluble in soils strictly on the basis of their inorganic chemical characteristics. Soluble, diffusible Pu in soils (usually less than 0. 1% of total) appears to be largely present as particulates of hydrated oxide, but several lines of evidence suggest that microorganisms may influence the solubility of Pu and that the nonparticulate plant-available fraction is stabilized in solution by inorganic or organic ligands of limited concentration in soil. The role of soil microorganisms in influencing the solubility, form and plant-availability of the transuranics is discussed on the basis of the (1) known chemistry of organic ligands in soils, (2) effects on the soil microflora, and (3) principal microbial transformation mechanisms, including direct alteration (valence state, alkylation), indirect alteration (metabolite interactions, influence on the physiochemical environment), and cycling processes (biological uptake and release on decomposition of tissues). The toxicity of Pu to microorganisms depends on Pu solubility in soil. However, soil microorganisms are generally resistant to Pu, with toxicity apparently due to radiation rather than chemical effects. Highly resistant bacteria, fungi, and actinomycetes have been isolated from soil, and these organisms have been shown to be capable of transporting Pu into the cell and altering its form in the cell and in solution. The resulting soluble Pu complexes tend to be of higher molecular weight than simple complexes (Pu-DTPA) and negatively charged. The form of Pu, although not well-defined, is dependent upon organism type, carbon source, and time of Pu exposure during growth. These factors, in turn, are a function of Pu source, soil properties, and soil environmental conditions. Knowledge of the relative influence of these factors serves as a valuable basis for predicting the long-term behavior of Pu and other transuranic elements in the terrestrial environment. (Authors) *Keywords:* NAEG*, soil property*, microbiota*, nutrition/diet*, radiation*

840 WILSON, R.H., R.G. THOMAS, and J.N. STANNARD. 1961. Biomedical and aerosol studies associated with a field release of plutonium. WT-1511, 70 pp.

On April 24, 1957, a high-explosive detonation was employed at the Nevada Test Site to release plutonium for field study of this fissionable material as a contaminant. One of four major measurements programs was a biomedical experiment which comprised exposure of animals to first deposition of plutonium oxide from the detonation cloud (acute subjects) and to the wind-induced resuspension of contamination (chronic subjects) as long as six months after original deposition. Acute subjects (26 dogs and 40 rats) were arrayed 500, 1,000, and 2,000 feet downwind from ground zero, and nine rats were flown on balloon cables positioned to intercept the cloud 500 feet from ground zero. Chronic subjects (three groups of 24 dogs and 3 burros) were placed, after a rough ground activity survey, at climatologically probable downwind segments of isopleths marking nominal contaminations of 1,000, 100 and 10 ugm of plutonium per square meter. Serial sacrifices of dogs were made at 4, 5, 16, 32, 64, 128, and 161 days after detonation. Ten tissues per animal were assayed by radiochemistry and autoradiography for plutonium content. All burros received the full 161-day exposure. Ten sheep were distributed among the three field positions on the 32nd day, at which time four additional dogs were placed at the middle position (100-line). All late animals stayed until the end of the maximum exposure period. Air samplers at each chronic field position documented daily mean air concentrations. The pattern of plutonium uptake was surprising in that statistically important numbers of acute and chronic animals showed significant bone burdens in an exposure situation for which lung alone was to have been the critical organ. This outcome was most unusual for acute animals sacrificed less than four hours postdetonation. In general, however, all uptakes were less than the forecast amounts. The factor of 100 difference between groundlevel contamination at near and far chronic stations brought uptake differences of less than a factor of ten to indicate that airborne material accumulates along the upwind path. Air centrations bear small if any relation to the "at foot" contamination for natural resuspension forces (wind). An explanation is advanced for the fact that, in an experiment designed to find time dependence in plutonium uptake, no tissues measured exhibited a correlation with exposure time, save GI tract and contents. The plutonium found in bone suggests some deviation from the pure oxide form (extremely insoluble in body fluids) and the presence of solubilizing influences either in early particulate formation or in animal lung. As yet no believable mechanism has been proposed. All autoradiography gave negative results. (Authors) *Keywords:* radionuclide inventory*, mammal*, radiation*

841 WINKEL, V.K. 1993. The Reclamation Program of the Treatability Studies for Soil Media Project (TSSM). Poster presented at 8th *Wildland Shrub and Arid Land Restoration Symposium, Nevada Test Site Field Tour.* CONF-9310276–8, EGG 11265-2027, EG&G Energy Measurements, Environmental Sciences Department, Las Vegas, NV.

The U.S. Department Of Energy is sponsoring a research and demonstration program on the Nevada Test Site to develop and test an optimized cleanup system for large-area, surface plutonium contamination. The project addresses three principle areas: vegetation and soil removal, volume reduction of the displaced soil, and site restoration consisting of soil stabilization and revegetation. Soil stabilization and revegetation are critical in order to prevent erosion and reestablish wildlife habitat. A series of field and laboratory studies have been initiated to develop technologies to stabilize and restore sites disturbed by TSSM activities. Soil stabilization studies will test suitable techniques and materials to control wind and water erosion. Revegetation studies will focus on determining suitable plant species, proper techniques for establishing plants by direct seeding, procedures for transplanting native shrubs, soil fertility and irrigation requirements, and effects of herbivory on plant establishment. Additional studies will determine the extent of plutonium contamination on native vegetation, and the potential for removing plutonium from vegetation. Laboratory and greenhouse studies will determine effects of plutonium decontamination processes on soil microbial populations, and the effects of gravel mulches and soil texture on plant establishment. Following completion of these studies, the most promising technologies will be demonstrated on a larger scale at actual contaminated sites on the NTS. (Author) *Keywords:* perturbations*, microbiota*, vegetation*, revegetation*, radiation*, methods*

842 WINKEL, V.K. 1995. Effects of Seed Origin and Irrigation on Survival and Growth of Transplanted Shrubs. Poster Presentation at 12th Annual Meeting of the American Society for Surface Mining and Reclamation, Gillette, WY, June 5-8, 1995. EG&G Energy Measurements.

Revegetation is difficult in the Mojave Desert due to limited erratic precipitation and extreme temperatures. Establishing plant cover by transplanting native shrubs is known to be a promising technique, but many questions still remain regarding its use on a large operational scale. A study was initiated on the U.S. Department of Energy Nevada Test Site (NTS) to determine the effects of seed origin and irrigation on survival and growth of transplanted shrubs. Plants of three species (*Larrea tridentata, Ambrosia dumosa*, and *Atriplex canescens*) were grown in a greenhouse and hardened outdoors. Plants of all three species were produced from two seed sources: (1) seed collected from the NTS (Mojave Desert), and (2) commercially available seed collected from outside the NTS*. One-year old containerized plants (180 of each species) were transplanted to a site on the NTS and irrigated with two liters of water at one of the following frequencies: (1) at time of planting only, (2) at time of planting and monthly during the first growing season, and (3) at time of planting and twice monthly during the first growing season. After 16 months, survival of all species was generally greater than 80% and was unaffected by irrigation treatments. Survival of fourwing saltbush was significantly greater from local versus non-local seed. Survival of bursage and creosotebush was generally unaffected by seed origin. Shrub volumes regardless of species or seed origin increased during the first growing season, and then decreased during the second growing season. Shrub volumes for fourwing saltbush were significantly greater for shrubs from local versus non-local seed. (Author) *Keywords:* hydrology*, perennial plants*, revegetation*

843 WINKEL, V.K., and J.L. BOONE. 1999. Effects of Irrigation on Emergence and Survival of Native Plant Seedlings at Yucca Mountain, Nevada. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5705-00080 Rev 00. Las Vegas, NV, 23 pp.

The U.S. Department of Energy has implemented a program to investigate the feasibility of various techniques for reclaiming lands disturbed during site characterization at Yucca Mountain. As part of this program, a study was conducted in 1995 and 1996 to determine whether recharge irrigation (irrigation to increase soil moisture prior to seed germination) or germination irrigation (irrigation to promote germination and plant establishment) could be used to enhance reclamation success during drought years. To examine the effects of irrigation, a site was prepared and 24 study plots were seeded in November 1995. Recharge irrigation was applied to twelve plots in early-February 1996 (80 mm of water); the remaining twelve plots received no recharge irrigation. Four germination irrigation treatments (10 mm twice weekly, 20 mm once weekly, 40 mm twice monthly, and no irrigation) were applied during March 1996 to six sites each. A total of 80 mm of water was applied to the plots receiving germination irrigation. The density of seedlings was measured in the spring (May 1996) to determine the effects of irrigation on seedling emergence. Seedling density was measured again in the fall (October 1996) to assess the influence of irrigation on plant establishment. In the spring, plots receiving recharge irrigation generally had lower densities of seeded-species, but higher densities of non-seeded annual forbs and grasses than plots not receiving recharge irrigation. This result may be attributable to frost kill of newly germinated seedlings during an unexpected period of freezing temperatures in late-February or to competition with annual plants. Plots receiving germination irrigation generally had higher densities of seedlings than plots not receiving germination irrigation. In the fall, densities of seeded-species generally were lower than they had been in the spring, but the general patterns of plant density were the same: some germination irrigation was better than none, but recharge irrigation lead to lower plant densities or had no effect. Additional irrigation during the summer months may improve overall plant survival. Irrigation generally increased plant emergence and survival over non-irrigation. For this reason, irrigation shows promise to enhance reclamation success at Yucca Mountain. In addition, species diversity generally was higher on irrigated plots. In the fall, there were 13-15 species on plots receiving some irrigation, but there were only four species on plots not receiving irrigation. Increased plant density and increased species diversity resulting from irrigation during drought years could improve long-term success of reclamation activities at Yucca Mountain. (Authors) *Keywords:* YMSCO*, hydrology*, perennial plants*, revegetation*

844 WINKEL, V.K., and W.K. OSTLER. 1994. Effects of topsoil removal on seedling emergence and species diversity. Presented at Annual meeting of the Society for Range Management, Colorado Springs, CO, 13-18 Feb 1994. EGG-11265-2017, CONF-940282-1, EG&G Energy Measurements, Environmental Sciences Department, Las Vegas, NV.

Approximately 800 hectares on the US Department of Energy Nevada Test Site and vicinity are contaminated with plutonium. As part of a cleanup effort, both the vegetation and the top 5-10 cm of soil may be removed. A study was developed to determine the effects of topsoil removal on seedling emergence and plant species diversity. Trial plots were prepared by removing 5, 10, or 20 cm of topsoil, seeding a mix of nine native species, mulching with straw, and then anchoring the straw with erosion netting. Additional plots (0 topsoil removal treatment) were lightly bladed to remove existing vegetation and then treated as above. Approximately 85 mm of supplemental irrigation was applied to help initiate germination during early spring. Seedling density data of seeded and nonseeded species was collected following emergence, and species diversity was calculated with the Shannon diversity index for the nonseeded species. Densities of seeded species either were unaffected by or increased with increased depth of topsoil removal. In general, densities of nonseeded species decreased with increased depth of topsoil removal. The number of species, species diversity and evenness also decreased with increased depth of topsoil removal. Initial emergence of seeded species is apparently unaffected by topsoil removal at this site. (Authors) *Keywords:* hydrology*, perturbations*, perennial plants*, revegetation*

845 WINKEL, V.K., W.K. OSTLER, W.D. GABBERT, and G.E. LYON. 1994. Effects of seedbed preparation, irrigation, and water harvesting on seedling emergence at the Nevada Test Site. Proceedings: *8th Wildland Shrub and Arid Land Restoration Symposium.* CONF-9310276–6, EGG 11265-1062, EG&G Energy Measurements, Environmental Sciences Department, Las Vegas, NV.

Approximately 800 hectares on the U.S. Department of Energy Nevada Test Site and vicinity are contaminated with plutonium. As part of a cleanup effort, both the indigenous vegetation and the top 5-10 cm of soil may be removed, and the soil may or may not be replaced. Technologies must be developed to stabilize and revegetate these lands. A study was developed to determine adaptable plant species, methods to prepare seedbeds for direct seeding and water harvesting and proper irrigation rates. Plots were cleared of indigenous vegetation, and then prepared with various seedbed/water harvesting treatments including, pitting, land imprinting, and mulching. Other plots were treated with large water harvesting structures. Three irrigation treatments were superimposed over the seedbed/water harvesting treatments. Seedling emergence data was collected and the treatment combinations compared. Supporting meteorological and soil data were collected with an automatic datalogger. Specific data included precipitation, and air temperature. In a year of above-average precipitation, irrigation did not generally aid germination and emergence of seeded species, and only slightly increased densities of species from the native seedbank. With the exception of increased shrub seedling densities in desert strips, there were no strong seedbed preparation/water harvesting treatment effects. In years of above-average rainfall, mulching and water harvesting treatments, and irrigation may not be necessary to insure adequate germination and emergence of adapted perennial grasses, forbs, and shrubs in the Mojave/Great Basin Transition Desert. Future collection of survival data will determine whether a maintenance irrigation program is necessary to ensure establishment of native plants. (Authors) *Keywords:* climate*, hydrology*, perennial plants*, revegetation*

846 WINKEL, V.K., J.P. ANGERER, D.B. HALL, M.W. FARISS, and K.R. JOHNEJACK. 1995. Plant and Burrowing Animal Characteristics, Integrated Closure Program for the Area-3 and Area-5 Radioactive Waste Management Sites, Nevada Test Site, Draft Report. U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV.

The Environmental Restoration and Technology Development Department of Reynolds Electrical & Engineering Co., Inc. is developing conceptual designs for covers on low level radioactive and mixed waste disposal units at the Radioactive Waste Management Sites in Area 3 and 5 of the Nevada Test Site (NTS). As part of the conceptual design process, a literature review was needed to determine pertinent characteristics of plants and animals that may influence the conceptual design of the covers and aid in the determination of parameters for simulation models. Only those characteristics that relate to biointrusion or soil water dynamics within a cover were reviewed. Eighteen species of NTS perennial plants, predominantly shrubs and grasses, were selected for literature review. The parameters reported on included for each reviewed species included plant height, above-ground biomass, depth of root system, lateral root spread, root biomass, roo:shoot ratios, transpiration rates when stressed and not stressed, drop tolerance, and xylem potentials. Fourteen species of mammals were chosen for review. Those parameters reported on from the literature review included: mammal densities, soil preferences for burrow sites, burrow depths, burrow lateral lengths, burrow densities, and the volume of soil removed during burrow excavation. Twenty species of ants were reviewed. Nest site preferences for NTS ant species include open areas, at shrub bases, beneath stones or rocks, or within nests created by other ants. Nest depths ranged from 0.15 m (0.5 ft) for *Pogonomyrmex californicus* and 3.4 m (11.2 ft) for *Veromessor pergandei*. Information on lateral length of nests, volume of soil excavated, and nest density could not be found for the majority of species reviewed in this report.

(CAW) (Authors) *Keywords:* perennial plants*, invertebrate*, mammal*, ecology/ecosystem*

847 **WINKEL, V.K., K.W. BLOMQUIST, J.P. ANGERER, M.W. FARISS, and W.K. OSTLER. 1999. Reclamation Feasibility Studies at Yucca Mountain, Nevada: 1992-1995. U.S. Department of Energy, Civilian Radioactive Waste Management System Management and Operation Contractor Report B00000000-01717-5700-00003 Rev 00. Las Vegas, NV, 184 pp.**

The U.S. Department of Energy (DOE) is characterizing the suitability of Yucca Mountain in Nye County, Nevada as a potential geologic repository for high-level nuclear waste. As part of its commitment to reclaim land disturbed by characterization activities, the DOE conducted a series of studies during the period from 1992 to 1995 to determine the feasibility of using various reclamation techniques for restoring vegetation on disturbances. To determine which reclamation feasibility studies would be most appropriate for implementation at Yucca Mountain, current literature in the field of arid land reclamation was reviewed and arid land reclamation scientists and experts were contacted to solicit their views. Information gathered during this process was used to identify specific treatments and factors for testing in the feasibility studies. This process resulted in the implementation of 10 reclamation feasibility studies that addressed reclamation techniques such as reduction of herbivory, mulching, polyacrylamide gel application, seeding method, water harvesting, topsoil application methods, topsoil substitutes, use of transplants, seeding rates, and irrigation. The studies were implemented at eight study areas: Sites 1, 3, 4, and 5, JF-3 Drill Pad, Trench A'2, the Precast Yard Topsoil Stockpile, and the Exploratory Studies Facility Topsoil Stockpile. The design and results of studies are presented. Initial results have shown that several reclamation methods show promise for use at Yucca Mountain and that direct seeding of native species is feasible in the Mojave Desert, especially during years having average and above-average precipitation. However, most of these studies were implemented during periods of above average rainfall and this may account for much of the initial success of the studies reported in this document. The continuing goal for the reclamation program at Yucca Mountain will be to repeat these successes in years with below average rainfall. (Authors) (CAW) *Keywords:* YMSCO*, hydrology*, perturbations*, perennial plants*, revegetation*

848 **WIRTH, S., and T.J. BROWN. 1999. Native Plant Uptake Model for Radioactive Waste Disposal Areas at the Nevada Test Site. SAND98-1789, IT Corporation and Sandia National Laboratory, Albuquerque, NM.**

This report defines and defends the basic framework, methodology, and associated input parameters for modeling plant uptake of radionuclides for use in Performance Assessment (PA) activities of Radioactive Waste Management Sites (RWMS) at the Nevada Test Site (NTS). PAs are used to help determine whether waste disposal configuration meet applicable regulatory standards for the protection of human health, the environment, or both. The plant uptake model presented reflects rooting characteristics important to plant uptake, biomass turnover rates, and the ability of plants to uptake radionuclides from the soil. Parameters are provided for modeling plant uptake and estimating surface contaminant flux due to plant uptake under both current and potential future climate conditions with increased effective soil moisture. Surface flux is modeled here as the amount of soil contamination that is transferred from the soil by roots and incorporated into aboveground biomass. Movement of contaminants to the surface is the only transport mechanism evaluated with the model presented here. Parameters necessary for estimating surface contaminant flux due to native plants expected to inhabit the NTS RWMS are developed in this report. The model is specific to the plant communities found at the NTS and is designed for both short-term (<1,000 years) and long-term (>1,000 years) modeling efforts. While the model has been crafted for general applicability to any NTS PA, the key radionuclides considered are limited to the transuranic wastes disposed of at the NTS. (Authors) *Keywords:* vegetation*, nutrition/diet*, radiation*, methods*

849 **WOODWARD, B. 1994. Reptile Populations on the Nevada Test Site in 1993. In: Status of the Flora and Fauna on the Nevada Test Site, 1993. Hunter, R.B. (Compiler), DOE/NV/11432-162, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 1-35.**

Lizard populations were studied in relatively undisturbed baseline areas and disturbed study areas in 1993. This was a relatively wet year, and lizard numbers appeared high relative to historical norms. Correlations between number of side-blotched lizards and year of study were nonsignificant on undisturbed baseline areas, implying lizards have not been undergoing a long term decline on the Nevada Test Site. Inspection of the data suggests the nonsignificance of the relationship is an outcome of small sample sizes (few years of study) and large yearly fluctuations, and implies the overall trend is towards an increase in side-blotched lizard numbers at most study areas. Ancillary evidence suggests the fluctuations are likely a response to rainfall levels over the years of monitoring. Study of disturbed areas and their associated controls revealed a different pattern. Areas disturbed by fire, roadside grading, or grading and other construction associated activities, all contained reduced lizard populations relative to nearby undisturbed areas. These effects appear to be the major consequence of DOE activities on lizards at the Nevada Test Site. (Author) *Keywords:* perturbations*, climate*, reptile*, ecology/ecosystem*

850 **WOODWARD, B. 1994. Status of Reptile and Amphibian Populations on the Nevada Test Site, 1992. In: Status of the Flora and Fauna on the Nevada Test Site, 1992. Hunter, R.B. (Compiler), DOE/NV/11432-58, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 31-83.**

In 1992, lizard densities were examined on two baseline plots on the NTS (YUF001, PAM001), and on three disturbed plots in subsidence craters and their three associated control plots (YUF019-24). The study focused on the side-blotched lizard, *Uta stansburiana*. *Uta* densities on baseline plots in 1992 fell within the range of *Uta* estimates in past years, implying numbers are remaining relatively constant. PAM001 on Pahute Mesa and YUF001 on Yucca Flat are the two most studied plots. These plots have been through a complete predrought - drought - postdrought cycle over the last six years. Adult and juvenile *Uta* densities differed across the predrought, drought, and postdrought periods, and adult densities were on average higher on Pahute Mesa relative to Yucca Flat. The effect of drought on lizards was not consistent across the two plots. The drought had essentially no effect on average adult *Uta* densities on Yucca Flat, and was associated with an increase in density on Pahute Mesa. Densities of juvenile *Uta* were markedly lower during the drought. Adult and juvenile snout-vent lengths (SVLs), and weights also differed across sites and drought regimes. Drought effects on juvenile SVL were not consistent across sites and drought regimes, whereas differences between sites in adult SVLs were consistent across years. Adult *Uta* on Pahute Mesa were slightly longer but almost 20 % heavier than adults on Yucca Flat. Adult *Uta* were approximately 15 % heavier during the postdrought period relative to the predrought or drought periods. Weight/SVL, an estimate of leanness was higher for adults on Pahute Mesa than on Yucca Flat, and higher after the drought than before or during it. This implies that conditions may be harsher for lizards at low elevation sites, and during or prior to the drought. Juvenile *Uta* were 14 % longer and 40 % heavier on Pahute Mesa relative to those on Yucca Flat. Similarly, juvenile weight/SVL, was 30 % lower on Yucca Flat relative to Pahute Mesa. Juvenile *Uta* were about 5 % shorter and 22 % lighter during the drought relative to pre- or postdrought periods. Juvenile weight/SVL was about 8 % lower during the drought relative to the periods before or after it. Finally, neither adult nor juvenile ages differed across sites or across drought regimes. These results suggest that drought has a major effect on lizard traits and on lizard densities, and that site specific factors (e.g., history of human use, elevation, vegetative cover) can have large effects on how drought can influence lizards. Mark-recapture studies of *Uta* in subsidence craters suggest that adult densities were lower in 1992 relative to 1989 whereas juvenile densities appear to show a reversed pattern. Spring and summer *Uta* populations are quite different, with the summer population on average containing more, younger and smaller individuals relative to the spring population. This implies that perturbations in different seasons could lead to markedly different effects on a *Uta* population. Our three measures of adult body size (SVL, weight, weight/SVL) all differed across years with larger lizards present in 1992 (a normal precipitation year) relative to 1989 (a drought year). The pattern was not consistent across treatments with differences across years more exaggerated in subsidence craters relative to control plots, suggesting that the craters were amplifying the drought effects. Juvenile weight and juvenile weight/SVL also were higher in 1992 relative to 1989. Both sets of differences imply that the drought in 1989 was hard on *Uta*. Adult *Uta* on the control plots were approximately 10 % heavier than adult *Uta* in subsidence craters; this relatively large difference was marginally nonsignificant. The number of juveniles on the control plots was also nonsignificantly greater than those in the subsidence craters. Finally, adult weight/SVL was almost 15 % greater for *Uta* on control plots as opposed to individuals in the subsidence craters. The subsidence crater results suggest that crater formation may have a negative effect on *Uta*, and that the effect is approximately as large as that imposed by drought. (Author) *Keywords:* climate*, perturbations*, reptile*, ecology/ecosystem*

851 **WOODWARD, B. 1995. Status of Reptiles on the Nevada Test Site, 1994 and Summary of Work 1987-1994. In: Status of the Flora and Fauna on the Nevada Test Site, 1994. Hunter, R.B. (Compiler), DOE/NV/11432-195, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, pp. 1-75.**

This report summarizes reptile studies performed by the Basic Environmental Compliance and Monitoring Program (BECAMP) on the Nevada Test Site (NTS) from 1987 to 1994. These studies were designed to assess Department of Energy (DOE) impacts on reptiles, monitor changes in lizard populations over time, and evaluate lizard sampling techniques. Reptile studies concentrated on lizards, in particular the abundant *Uta stansburiana* (uta). The NTS lizard work took place at both largely undisturbed baseline sites, which are well removed from DOE projects, and at disturbed sites proximal to DOE projects and at their nearby controls. Baseline studies revealed sizeable temporal fluctuations in lizard densities, lizard body sizes, and reproductive characteristics. Populations crashed and returned to high levels over two to three years. On most baseline plots, there was neither a consistent increase nor decrease in uta density over this study. Instead, numbers rose and fell rapidly and inconsistently implying no long-term indirect impacts of DOE activities on lizard populations. There was some suggestion that these patterns may be driven by rainfall. There also was tremendous spatial variation in uta traits across the largely undisturbed baseline sites. Basin bottoms tended to contain many fewer uta relative to foothills areas. These differences suggest that future sampling approaches should involve widely dispersed and numerous sample sites in order to fully represent the range of uta populations. Results at disturbed sites revealed sizeable direct effects of DOE activities. Comparisons of burned, blasted, cratered, graded, or paved areas with their appropriate control areas revealed sizeable negative effects of DOE activities on lizards. All of these activities removed the perennial vegetation, a major component of lizard habitat, suggesting that habitat removal is the proximal mechanism involved. At some sites, like the above-ground blast sites and the below-ground blast sites that breached the surface, effects on lizards may also have been caused by release of radioactive material. The majority of these DOE activities took place at least 10 years ago and many greater than 20 years ago, yet uta have still not recovered. This is probably because the habitat itself has not recovered. At present, the spatial extent of these effects on the NTS is not known. (Author) *Keywords:* climate*, perturbations*, reptile*, ecology/ecosystem

852 **WOODWARD, B., R.B. HUNTER, P.D. GREGER, and M.B. SAETHRE. 1995. The 1993 Baseline Biological Studies and Proposed Monitoring Plan for the Device Assembly Facility at the Nevada Test Site, DOE/NV 11432-163, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV.**

This report contains baseline data and recommendations for future monitoring of plants and animals near the new Device Assembly Facility (DAF) on the Nevada Test Site (NTS). The facility is a large structure designed for safely assembling nuclear weapons. Baseline data was collected in 1993, prior to the scheduled beginning of DAF operations in early 1995. Studies were not performed prior to construction and part of the task of monitoring operational effects will be to distinguish those effects from the extensive disturbance effects resulting from construction. Baseline information on species abundances and distributions was collected on ephemeral and perennial plants, mammals, reptiles, and birds in the desert ecosystems within three kilometers (km) of the DAF. Particular attention was paid to effects of selected disturbances, such as the paved road, sewage pond, and the flood-control dike, associated with the facility. Radiological monitoring of areas surrounding the DAF is not included in this report. (Authors) *Keywords:* perturbations*, annual plants*, perennial plants*, bird*, reptile*, mammal*, ecology/ecosystem

853 **WOODWARD, B., R.B. HUNTER, P.D. GREGER, and M.B. SAETHRE. 1995. 1994 Baseline Biological Studies for the Device Assembly Facility at the Nevada Test Site, DOE/NV/11432--177, Reynolds Electrical & Engineering Co., Inc., Las Vegas, NV, 31 pp.**

Biological surveys of plants, reptiles, birds, and small mammals continued in 1994, with emphasis on examining spatial and temporal variation in these groups in the Device Assembly Facility (DAF) vicinity. The DAF was still in a preoperational phase in 1994. To date, the main ecological DAF impacts have been removal of the perennial plant community by grading (for the access road, the building sites, parking lots, and construction staging areas), and addition of water to the sewage settling ponds. Grading removed the plants (creating habitat for weedy plant species), and removed habitat for animals. Adding water to the sewage ponds increased bird use of the DAF area. As in 1993, *Uta stansburiana* (uta) densities were lower in graded areas immediately surrounding the DAF building complex relative to largely undisturbed areas nearby. Uta densities were also lower in largely undisturbed areas southwest of the DAF relative to undisturbed areas to the northeast of the DAF building complex. No chuckwallas or live tortoises were seen within 400 m of the DAF building complex. The small mammal community to the southwest of the DAF building complex contained the same number of species and had a similar species diversity to the one northeast of the DAF building complex. This contrasted with 1993 results when the small mammal community to the southeast differed greatly from the one to the northwest. Bird densities were markedly lower in 1994 relative to 1993, as they were test-site wide. Bird reproduction near the DAF was essentially nonexistent in 1994. Plant results were largely similar in 1993 and 1994. There was some evidence that preoperational DAF activities reduced plant growth near the facility. The results across all studied taxa suggest that the DAF is located in a transitional area with different floral and faunal communities on different sides. The

ramifications of this for monitoring impacts are discussed. (Authors) *Keywords:* perturbations*, vegetation*, bird*, reptile*, mammal*, ecology/ecosystem

854 **WOODWARD, R., K.R. RAUTENSTRAUCH, D.B. HALL, and W.K. OSTLER. 1998. The Relative Abundance of Desert Tortoises on the Nevada Test Site Within Ecological Landform Units. DOE/NV/11718–245, Bechtel Nevada, Las Vegas, NV, 23 pp.**

Sign-survey transects were sampled in 1996 to better determine the relative abundance of desert tortoises on the Nevada Test Site (NTS). These transects were sampled within ecological landform units (ELUs), which are small, ecologically homogeneous units of land. Two-hundred and six ELUs were sampled by walking 332 transects totaling 889 kilometers (km) (552 miles [mi]). These ELUs covered 528 km^2 (204 mi^2). Two-hundred and eighty-one sign were counted. An average of 0.32 sign was found per km walked. Seventy percent of the area sampled had a very low abundance of tortoises, 29 percent had a low abundance, and 1 percent had a moderate abundance. A revised map of the relative abundance of desert tortoise on the NTS is presented. Within the 1,330 km^2 (514 mi^2) of desert tortoise habitat on the NTS, 49 percent is classified as having no tortoises or a very low abundance, 18 percent has a low or moderate abundance, 12 percent is unclassified land being used by the Yucca Mountain Site Characterization Project, and the remaining 21 percent still has an unknown abundance of desert tortoises. Based on the results of this work, the amount of tortoise habitat previously classified as having an unknown or low-moderate abundance, and on which clearance surveys and on-site monitoring was required, has been reduced by 20 percent. (Authors) *Keywords:* desert tortoise*, ecology/ecosystem*

855 WORMAN, F.C. 1965. Anatomy of the Nevada Test Site. Los Alamos Scientific Laboratory Pamphlet, 32 pp.

The human history and salvage archeology as well as geology and climatology of the Nevada Test Site are reviewed. The biology section separates the flora into perennials and annuals and elevations at which they grow. Animals of the Nevada Test Site included are centipedes, arachnids, scorpions, reptiles, birds and mammals. (HP) *Keywords:* climate*, geology*, annual plants*, perennial plants*, invertebrate*, bird*, reptile*, mammal*, ecology/ecosystem*

856 WORMAN, F.C.V. 1969. Archeological investigations at the U.S. Atomic Energy Commission's Nevada Test Site and Nuclear Rocket Development Station. LA-4125, 201 pp.

The archeology of southeastern Nye County, Nevada, which contains both the Nevada Test Site and the Nuclear Rocket Development Station was investigated. The biology, geology, and history of the NTS are discussed briefly. Then each of 17 archeological sites is described as to location, formation, and contents of archeological interest. These descriptions are illustrated with numerous photographs of the sites and the artifacts found therein. (LCL) *Keywords:* geology*, ecology/ecosystem*

857 YODER, C.K., and R.S. NOWAK. 1999. Competition for phosphorus between an exotic annual grass and Mojave Desert shrubs. In: Symposium Abstracts, The Ecological Society of America 84th Annual Meeting, August 8-12, 1999, Spokane, WA.

Bromus madretensis ssp. rubens (red brome) is an invasive annual grass that is associated with increases in fire frequency and decreases in perennial plant diversity in the Mojave Desert. In this dual-isotope study, red brome acquired more than three times as much phosphorus from soil interspaces shared with the evergreen shrub *Larrea tridentata* than from soil interspaces shared with the deciduous shrub *Ambrosia dumosa*. There were no differences in the amount of phosphorus acquired by red brome from soil interspaces shared with *Larrea* versus soil interspaces shared with a second drought deciduous shrub *Lycium pallidum*. Greater phosphorus uptake by red brome from soil interspaces shared with *Larrea* versus soil interspaces shared with *Ambrosia* suggests greater competitive effectiveness of *Ambrosia* relative to *Larrea* to deplete soil resources at the expense of red brome. Although red brome biomass did not differ significantly beneath different shrub canopies, total annual plant biomass was significantly lower ($P< 0.05$) beneath *Ambrosia* canopies relative to *Larrea*. No significant differences in annual plant biomass occurred beneath *Lycium* canopies relative to *Larrea*. Plants that acquire phosphorus effectively should have a competitive advantage over species that do not. The results of this dual-isotope study suggest that lower annual plant biomass under *Ambrosia* canopies relative to *Larrea* and *Lycium* may be due in part to *Ambrosia's* greater competitive effectiveness at depleting below-ground phosphate at the expense of annuals. (Authors) *Keywords:* invasive species*, annual plants*, perennial plants*, nutrition/diet*

858 YODER, C.K., and R.S. NOWAK. 1999. Hydraulic lift among native plant species in the Mojave Desert. Plant Soil 215:93-102.

Hydraulic lift was investigated among native plants in the Mojave Desert using in situ thermocouple psychrometers. Night fighting and day shading experiments were used to verify the phenomenon. Hydraulic lift was detected for all species examined: five shrub species with different rooting depths and leaf phenologies and one perennial grass species. This study was the first to document hydraulic lift for a CAM species, *Yucca schidigera*. The pattern of diel flux in soil water potential for the CAM species was temporally opposite to that of C_3 species: for the CAM plant, soil water potential increased in shallow soils during the day when the plant was not transpiring and decreased at night when transpiration began. Because CAM plants transport water to shallow soils during the day when surrounding C_3 and C_4 plants transpire, CAM species that hydraulically lift water may influence water relations of surrounding species to a greater extent than hydraulically lifting C_3 or C_4 species. A strong, negative relationship between the percent sand in the study site soils at the 0.35 m soil depth and the frequency that hydraulic lift was observed at that depth suggests that the occurrence of hydraulic lift is negatively influenced by coarse-textured soils, perhaps due to less root-soil contact in sandy soils relative to finer-textured soils. Differences in soil texture among study sites may explain, in part, differences in the frequency that hydraulic lift was detected among these species. Further investigations are needed to elucidate species versus soil texture effects on hydraulic lift. (Authors) *Keywords:* climate*, soil property*, perennial plants*, physiology*

859 **YODER, C.K.. and R.S. NOWAK. 1999. Soil moisture extraction by evergreen and drought-deciduous shrubs in the Mojave Desert during wet and dry years. Journal of Arid Environments 42:81-96.**

Annual and seasonal evapo-transpiration (ET) were compared among Mojave Desert shrubs with different leaf phenologies over a 3-year period during which annual precipitation varied from well below average to more than twice average. During the wet year, soil wetting fronts reached maximum depths of 0.75 m to > 1.95 m, depending on soil texture at the study sites. The evergreen shrubs *Larrea tridentata* and *Ephedra nevadensis*, and the drought deciduous shrub *Ambrosia dumosa*, were able to extract soil water in a uniform manner to depths > 1 m. For stands of the deciduous shrub *Lycium pallidum*, a soil texture change at c. 0.75 m impeded percolation of water below that depth. There were no significant differences ($p < 0.05$) in annual ET between the evergreen shrubs *Larrea* and *Ephedra* relative to the drought-deciduous shrubs *Ambrosia* and *Lycium* during the 3 years of the study. Early in the growing season, extraction of soil water from beneath plant canopies was slightly greater than from shrub interspaces for *Ambrosia, Ephedra*, and *Lycium*, but not for *Larrea*. For all species, annual soil water extraction from beneath plant canopies was not significantly different than that from shrub interspaces. The lower limit of soil water extraction (L_e) for the study sites varied from 4 to 10 volumetric per cent, depending on soil texture, and did not differ significantly among species. For all species, L_e was reached within 6 to 12 months following twice average precipitation during the period of November 1994 to March 1995. We conclude that ET in the Mojave Desert is dependent largely on winter precipitation and the amount of soil water available during the growing season rather than on species composition. (Authors) *Keywords:* climate*, soil property*, perennial plants*, physiology*

860 **YODER, C.K., and R.S. NOWAK. 2000. Phosphorus acquisition by *Bromus madritensis* ssp. *rubens* from soil interspaces shared with Mojave Desert shrubs. Functional Ecology 14:685-692.**

Bromus madritensis ssp. *rubens* (L.) Husnot (Red Brome) is an invasive annual grass that is associated with increases in fire frequency and decreases in perennial plant diversity. The success of Red Brome in the Mojave Desert has been attributed to its competitive ability, but competition between Red Brome and native shrubs for below-ground resources has not been investigated previously. In this study we present a modification of previous dual-isotope methods that assesses competitive interactions and responses among plants under field conditions. We then use this method to (i) determine if direct competition for phosphorus (P) occurs between Red Brome and native shrubs, and (ii) evaluate the effectiveness of phosphate acquisition by Red Brome from soil interspaces shared with different Mojave Desert shrub species. Clipping Red Brome to remove≈85% of its foliage on the day prior to labeling soil interspaces with P isotopes did not have the desired effect of inhibiting phosphorus uptake by Red Brome. Therefore we were unable to verify that direct competition for P occurred between Red Brome and native shrubs. Nonetheless, by sampling plant tissue from unclipped strips of Red Brome that were centered between two shrubs, we were able to evaluate the effectiveness of phosphate acquisition by Red Brome from interspaces shared with different shrubs. There were no differences in the amount of phosphorus acquired by Red Brome from soil interspaces shared with the evergreen shrub *Larrea tridentata* (D.C.) Cov. versus soil interspaces shared with the drought deciduous shrub *Lycium pallidum* Miers. However, Red Brome acquired more than six times as much P from soil interspaces shared with Larrea than from soil interspaces shared with the drought deciduous shrub *Ambrosia dumosa* Payne. Less P uptake by Red Brome from soil interspaces shared with *Ambrosia* suggests greater effectiveness of *Ambrosia* compared with *Larrea* to deplete soil P. (Authors) *Keywords:* climate*, soil property*, invasive species*, annual plants*, perennial plants*, nutrition/diet*

861 **YOUNG, R.A. 1972. Water supply for the Nuclear Rocket Development Station, at the U.S. Atomic Energy Commission's Nevada Test Site. USGS Water Supply Paper No. 1938, 19 pp.**

The Nuclear Rocket Development Station, in Jackass Flats, occupies about 123 square miles in the southwestern part of the U.S. Atomic Energy Commission's Nevada Test Site. Jackass Flats, an intermontane valley bordered by highlands on all sides except for a drainage outlet in the southwestern corner, has an average annual rainfall of 4 inches. Jackass Flats is underlain by alluvium, colluvium, and volcanic rocks of Cenozoic age and, at greater depth, by sedimentary rocks of Paleozoic age. The alluvium and the colluvium lie above the saturated zone throughout nearly all of Jackass Flats. The Paleozoic sedimentary rocks contain limestone and dolomite units that are excellent water producers elsewhere; however, these units are too deep in Jackass Flats to be economic sources of water. The only important water-producing unit known in the vicinity of the Nuclear Rocket Development Station is a welded-tuff aquifer, the Tonopah Spring Member of the Paintbrush Tuff, which receives no significant recharge. This member contains about 500 feet of highly fractured rock underlying an area 11 miles long and 3 miles wide in western Jackass Flats. Permeability of the aquifer is derived mostly from joints and fractures; however, some permeability may be derived from gas bubbles in the upper part of the unit. Transmissivity, obtained from pumping tests, ranges from 68,000 to 488,000 gallons per day per foot. Volume of the saturated part of the aquifer is about 3.5 cubic miles, and the average specific yield probably ranges from 1 to 5 percent. The volume of groundwater in storage is probably within the range of 37-187 billion gallons. This large amount of water should be sufficient to supply the needs of the Nuclear Rocket Development Station for many years. Water at the Nuclear Rocket Development Station is used for public supply, construction, test-cell coolant, exhaust cooling, and thermal shielding during nuclear reactor and engine testing, and washdown. Present (1967) average consumption of water is 520,000 gallons per day -- all supplied by one well. This supply well and a standby well have a production capability of 1.6 million gallons per day -- adequate for present needs. Water in the welded-tuff aquifer is of the sodium bicarbonate type. Dissolved solids content of the water in Jackass Flats is in the general range 230 milligrams per liter in the western part to 890 milligrams per liter in the eastern part. Personal communication from the author dated March 16, 1973, relates the following: As the report was written in 1968, the data is not quite up-to-date. Well J-12 was deepened in August 1968 to 1,000 ft and will now produce 1,000 gallons per minute with less than 20 ft of drawdown. Further, when the pump was pulled in 1968, it was found that the water level was the same as in 1952 when the well was drilled; therefore, there is no decrease in storage as indicated in the report. Because the wells have been on standby since the National Rocket Development Station has been deactivated, a maximum amount of storage should be anticipated at this time. (Author)
Keywords: geology*, hydrology*, ecology/ecosystem*

862 **YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT. 1992. Environmental Field Activity Plan for Terrestrial Ecosystems. YMP/91-41. U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Las Vegas, NV.**

The purpose of the Terrestrial Ecosystems EFAP is to describe the radiological and ecological field studies that will be conducted at Yucca Mountain. The primary objectives of these studies are: (1) To monitor and mitigate any potentially adverse effects to important plant and animal species caused by SCA, (2) To support the YMP Radiological Monitoring Plan (RMP) by providing samples and information on species used to monitor levels and pathways of radionuclides in the environment, (3) To provide information on ecological parameters of native plant and animal populations to evaluate SCA effects on the environment, and (4) To ensure compliance with applicable environmental regulations. This EFAP provides the following information: (1) regulatory requirements to follow during implementation of the environmental program, (2) description of the study area, (3) field study designs, (4) justification for studies and their design, (5) description of field methods, (6) analysis of field data, (7) schedules and milestones for each study, (8) organization conducting work and their support to other programs, and (9) quality assurance. (Authors) *Keywords:* YMSCO*, management*, perturbations*, vegetation*, vertebrate*, ecology/ecosystem*

863 **ZITZER, S., J. ARNONE, R. NOWAK, J. SEEMANN, and S. SMITH. 2000. Litter accumulation beneath Mojave Desert shrubs exposed to predicted 21st century atmospheric CO_2 levels using Free Air CO_2 Enrichment (FACE). In: Symposium Abstracts, The Ecological Society of America 85th Annual Meeting, August 6-10, 2000, Snowbird, UT.**

Deserts are predicted to have the largest relative increases in primary productivity due to rising atmospheric CO_2. Therefore, we began continuous exposure of an undisturbed Mojave Desert plant community to 550 ppm CO_2 using FACE (Free Air Carbon Dioxide Enrichment) technology in April 1997. Perennial cover in our study plots was dominated by *Larrea tridentata*, an evergreen shrub, and the deciduous shrubs *Ambrosia dumosa*, *Lycium andersonii* and *Lycium* *pallidum* accounting for 64% of total perennial cover. Our experimental design consisted of 9 circular 23 m diameter plots, 3 fumigated with 550 ppm CO_2, 3 controls fumigated with ambient CO_2 and 3 controls with no fumigation. Paired litter trays, (25 by 25 cm) were placed beneath 3 shrub canopies per species per plot in spring 1998. Litter was collected at 4-8 week intervals. For 1998, a wet year (309 mm rainfall), litter accumulation for all species under elevated CO_2 was significantly greater than under ambient CO_2, (161.5 ± 16.2 and 128.0 ± 9.3 g m^{-3} canopy volume< respectively). In contrast, 1999 was a dry year (107 mm rainfall) and litter for all species under elevated CO_2 was not significantly greater than under ambient CO_2, (57.0 ± 10.7 and 42.9 ± 5.7 g m^{-3} canopy volume< respectively). *Larrea* had significantly greater litter accumulation under elevated CO_2 during the wet year, (244.8 ± 21.0 g m^{-3}) than *L. pallidum* (158.2 ± 5.9), *Ambrosia* (119.8 ± 11.3) and *L. andersonii* (81.4 ± 6.2), which were not significantly different. Litter accumulation during the dry year was reduced by 50, 70, 77 and 91% for *Larrea*, *L. andersonii*, *Ambrosia* and *L. pallidum* , respectively, and the percent decrease was similar under both CO_2 levels. Litter quality varied greatly relative to proportions of leaf, wood and seeds. Increased litter accumulation under desert shrubs due to elevated CO_2 may represent a significant carbon sink under predicted levels of increasing atmospheric CO_2. (Authors) *Keywords:* FACE*, perturbations*, perennial plants*, ecology/ecosystem*

864 ZITZER, S.F., T. HUXMAN, T. CHARLET, D. STORTZ-LINTZ, and S. SMITH. 1999. Influence of exposure to elevated atmospheric CO_2 (FACE) on growth and reproduction by winter annuals in an undisturbed Mojave Desert site during a wet year. In: Symposium Abstracts, The Ecological Society of America 84th Annual Meeting, August 8-12, 1999, Spokane, WA.

Arid environments are expected to have large relative increases in primary productivity due to increasing levels of atmospheric CO_2 Despite low primary productivity by desert winter annuals, they cover large geographic areas. Consequently, an increase in primary productivity could represent a long term increase in arid ecosystem carbon sequestration. We began continuous exposure of a Mojave Desert plant community to 550 ppm CO_2 using FACE (Free Air Carbon Dioxide Enrichment) technology in April 1997. We measured biomass production by four dominant annuals, *Bromus madritensis* an introduced C_4 grass, two native forbs *Eriogonum trichopes* and *Lepidium lasiocarpum* and a native grass *Vulpia octoflora*. Peak biomass production under elevated CO_2 compared to ambient was greater for *Bromus* (70%), *Lepidium* (52%), and *Vulpia* (88%), but not for *Eriogonum*. Peak allocation of biomass to reproductive structures was not influenced by elevated CO_2, but plants began allocation to reproductive structures earlier in elevated CO_2 than in ambient CO_2. For all species, there was interaction of CO_2 with overstory type on total biomass and allocation patterns. Accurately predicting long term increases in carbon sequestration by desert annuals under increasing atmospheric CO_2 depends on collecting more long term data on the interactions of CO_2, precipitation patterns and soil resources. (Authors) *Keywords:* FACE*, perturbations*, invasive species*, annual plants*, perennial plants*, ecology/ecosystem*, physiology*

865 ZITZER, S.F., J. COLEMAN, D. JORDAN, R. NOWAK, J. SEEMANN, and S. SMITH. 1999. Litter accumulation beneath Mojave Desert shrubs exposed to predicted 21st century atmospheric CO_2 levels (FACE): Comparison of evergreen *Larrea tridentata* with various deciduous shrubs. Mojave Desert Science Symposium, Las Vegas, NV, February 25-27.

The Mojave Desert is the most arid ecosystem of North America. Some climate change models predict the driest ecosystems will have the largest relative increases in primary productivity due to rising atmospheric CO_2 levels. We began continuous exposure of an undisturbed Mojave Desert plant community to 550 ppm atmospheric CO_2 using FACE (Free Air Carbon Dioxide Enrichment) technology on April 28, 1997. The perennial plant community in our study plots was dominated by *Larrea tridentata* an evergreen shrub, and deciduous shrubs *Ambrosia dumosa*, *Lycium andersonii* and *Lycium pallidum*. Together these four species comprised 64% of the mean perennial plant cover of 77.1 m^2 per plot. The experimental design consisted of 9 circular 25m diameter plots with three plots fumigated with 550 ppm CO_2 , three control plots fumigated with ambient CO_2 and three control plots with no fumigation. Access to plants within the plots was via a specially designed apparatus which eliminated disturbance to the plants and soils. Paired litter trays, (0.0625 m^2) were placed beneath shrub canopies with northeast and southwest aspects on 28 April 1998 and canopy depths above the trays were measured. Litter samples were collected at 4 to 8 week intervals. On 1 February 1999 after 273 days, mean litter accumulation for all four species combined was 147.4, 119.0 and 110.3 g m-3 canopy volume for the 550 fumigation, non-fumigated and ambient fumigation plots respectively. However, the 29% increase in litter accumulation beneath shrubs in the elevated CO_2 plots was significantly greater than the controls plots only at alpha=0.19 because of the large variation between shrubs (coefficient of variation for the means ranged from 50-60%). Peak rates of litter accumulation for the deciduous shrubs occurred in July coincident with low soil moisture contents. Peak rates for *Larrea* occurred in September, but temporal variation was less for evergreen *Larrea* than for deciduous shrubs. Species composition in the litter samples varied from 100% of the overstory shrub species to a maximum of six species including annuals, grasses and other shrubs species. Litter quality varied greatly relative to proportions of leaf, wood and seed in the samples. For an above average rainfall year, litter accumulation represented an annual turnover of about 10% of the aboveground biomass. Considering low rates of decomposition in arid environments increases in litter accumulation under Mojave Desert shrubs due to elevated CO_2 may represent a significant carbon sink under predicted levels of increasing atmospheric CO_2. (Authors) *Keywords:* FACE*, perturbations*, perennial plants*, ecology/ecosystem*

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SPECIES LIST OF FLORA OF THE NEVADA TEST SITE

SPECIES LIST OF FLORA OF THE NEVADA TEST SITE

This section was compiled from citations *48, 86, 135, 168, 172, 245, 483, 507, 642,* and *717.* The species are arranged in alphabetical rather than taxonomic order to help the reader locate names more readily. The most current genus and species names of the vascular plants were used [507]. Names of taxonomic authorities were not included, but they can be found in the original source material cited above. Efforts were made to verify the taxonomic status of the nonvascular plants (see below). Those species whose names were unable to be verified are indicated with an asterisk. Common names were not included for any of the flora.

Voucher specimens of the vascular plants have been deposited in a number of herbaria including those at the University of Nevada, Reno; University of Nevada, Las Vegas; University of Cincinnati; Stanford University; and New York Botanical Garden.

All scientific names for nonvascular flora were taken from the following sources accessed on May 8, 2001:

http://www.itis.usda.gov/index.htmln - for Monera, Bacillariophyta, Chlorophycota, Xanthophyta
http://www.mycology.adelaide.edu.au/mycology/myco.nsf/ - for Fungi
http://plants.usda.gov/plants/index.html - for Gnetophyta, Magnoliophyta, Pteridophyta

NONVASCULAR FLORA

KINGDOM FUNGI

Alternaria tenuis
Antrodia serialis
Aspergillus fumigatus
A. niger
A. niveus
A. ochraceus
A. restrictus
A. sulfureus *
A. ustus
A. versicolor
A. wentii
Botrytis bassiana *
Bourdotia eyrei *
Cephalosporium sp.
Cephalosporium acremonium
C. humicola *
Chaetomium aureum
C. spirale`
Choanephora sp.
Circinella muscae *
Cladosporium cladosporioides
C. herbarum
Coccosporium sp. *
Cunninghamella bainieri *
C. microspora *
Curvularia sp. *
Cylindrocarpon heteronemum *
Fomitopsis pinicola
F. rosea
Fusarium semitectum
Geotrichum sp. *
Glipcladium penicilloides *
G. roseum *
Gloeocladium sp. *
Gymnoascus sp. *
Hormiscium sp. *
Leucogyrophana mollusca *
Mucor sp.
M. corticolus *
M. spinescens *
M. varians *
Myrothecium verrucaria *
Osteina obducta
Paecilomyces inflatus *
P. terricola *
Papularia sp. *
Papulospora sepedonioides *
Paxillus panuoides
Penicillium sp. *
P. avellanea *
P. granulatum
P. janthinellum
P. lanosum
P. oxalicum
P. restrictum
P. urtica *
Phoma sp.
Poria carbonica
P. placenta
P. vaillantii
Pullularia pullulans *
Pythium mammillatum *
Rhizopus stolonifer *
Serpula himantioides
Sporotrichum epigaeum *
Stachybotrys chartarum
Stemphylium ilicis *
Stysanus medicus *
Syncephalastrum racemosum
Tetracoccosporium paxianum *
Trichoderma harzianum
T. viride
Tyromyces transmutans *

KINGDOM MONERA

DIVISION BACTERIA (BACTERIA)

Streptomyces sp.

DIVISION CYANOPHYCOTA (BLUE-GREEN ALGAE)

Anacystis montana
Calothrix sp.
Coccochloris elabens
C. stagnina
Homoeothrix janthina
Leptolyngbya tenuis
Lyngbya sp.
Microcoleus paludosus
M. vaginatus
Nodularia sphaerocarpa
Nostoc sp.
N. commune
N. enthophytum *
Nostoc humifusum *
Oscillatoria sp.
O. brevis
Phormidium sp.
P. autumnale
Plectonema boryanum
P. nostocorum
Schizothrix accutissima *
S. californica *
S. macbridei *
Scytonema hofmannii
Symploca kieneri *

KINGDOM PLANTAE

DIVISION BACILLARIOPHYTA (DIATOMS)

Achnanthes exigua
A. lanceolata
A. minutissima
A. saxonica
Amphora submontana
Asterionella formosa
Denticula elegans
Epithemia adnata var. *proboscidea* *
E. sorex
Fragilaria sp.
F. construens
Gomphonema parvulum
Hantzschia sp.
Melosira granulata
Meridion circulare
Navicula cryptocephala
N. cuspidata var. *ambigua*
Navicula laevissima
N. minima
N. rhynchocephala var. *amphiceras*
Nitzschia sp.
N. amphibia
N. gracilis
N. linearis
N. palea
N. tryblionella
Pinnularia sp.
P. abaujensis var. *subundulata*
P. viridis var. *minor*
Stauroneis anceps
Stephanodiscus niagarae
Surirella ovalis

DIVISION CHLOROPHYCOTA (GREEN ALGAE)

Ankistrodesmus falcatus
Bulbochaete sp.
Chara sp.
Chlamydomonas sp.
Chlorella vulgaris
Closterium turgidum
Cosmarium sp.
Franceia droescheri
Haematococcus lacustris
Microthamnion kuetzingianum
Oedogonium sp.
Oocystis borgei
O. crassa
Pandorina morum
Protococcus grebillei *
Protoderma viride
Protosiphon cinnamomeus *
Scenedesmus acutus
S. bijuga
Spirogyra jurgensii
Stigeoclonium sp.
Ulothrix sp.

DIVISION XANTHOPHYTA (YELLOW-GREEN ALGAE)

Vaucheria sp.

* Designates species in which the listing was unable to be verified or updated.

VASCULAR FLORA

DIVISION CONIFEROPHYTA (CONIFERS)

Cupressaceae - Cypress Family

Juniperus osteosperma

Pinaceae - Pine Family

Pinus monophylla

DIVISION GNETOPHYTA (GNETOPHYTES)

Ephedraceae - Mormon-tea Family

Ephedra funerea
E. nevadensis
E. torreyana
E. viridis

DIVISION MAGNOLIOPHYTA (FLOWERING PLANTS)

Monocotyledons

Agavaceae - Century-plant Family

Agave utahensis var. *eborispina*
Yucca baccata var. *vespertina*
Y. brevifolia
Y. schidigera

Cyperaceae - Sedge Family

Bolboschoenus robustus
Carex alma
C. douglasii
C. occidentalis
C. praegracilis
Eleocharis macrostachya
E. parishii
E. paulustris
Schoenoplectus acutus var. *acutus*

Juncaceae - Rush Family

Juncus balticus
J. longistylis
J. saximontanus

Liliaceae - Lily Family

Allium nevadense
A. scorodoprasum
Androstephium breviflorum
Calochortus bruneaunis
C. flexuosus
Dichelostemma pulchellum
Fritillaria atropurpurea
Zigadenus paniculatus

Poaceae - Grass Family

Achnatherum aridum
A. coronatum
A. hymenoides
A. parishii
A. parishii var. *parishii*
A. pinetorum
A. speciosum
A. thurberianum
Agropyron cristatum
Agrostis exarata var. *monolepis*
A. semiverticillata
Aristida adscensionis

Poaceae - Grass Family (Cont'd)

Aristida arizonica
A. purpurea
A. purpurea var. *fendleriana*
A. purpurea var. *longiseta*
A. purpurea var. *nealleyi*
A. purpurea var. *wrightii*
Avena sativa
Blepharidachne kingii
Bouteloua barbata
B. gracilis
B. trifida
Bromus anomalus
B. berterianus
B. carinatus
B. cartharticus
B. diandrus
B. japonicus
B. rubens
B. tectorum
Chloris virgata
Cynodon dactylon
Dactylis glomerata
Deschampsia caespitosa
D. danthonioides
Digitaria sanguinalis
Distichlis spicata
Echinochloa crusgalli
Elymus elymoides ssp. *elymoides*
E. multisetus
Eragrostis barrelieri
Erioneuron pilosum
E. pulchellum
Festuca pratensis
Hesperostipa comata ssp. *comata*
Hordeum jubatum
H. murinum ssp. *glaucum*

Poaceae - Grass Family (Cont'd)

Koeleria macrantha
Leptochloa uninervia
Leymus cinereus
L. triticoides
Lolium arundinacea
L. perenne ssp. *multiflorum*
Monroa squarrosa
Muhlenbergia porteri
M. richardsonis
Pascopyrum smithii
Piptatherum micrantha
Pleuraphis jamesii
P. rigida
Poa annua
P. bigelovii
P. fendleriana
P. pratensis
P. secunda
Polypogon interruptus
P. monspeliensis
Puccinellia distans
Schismus arabicus
Setaria pumila
Sorghum halepense
Sporobolus cryptandrus
S. flexuosus
Tridens muticus
Vulpia microstachys
V. myuros
V. octoflora

Potamogetonaceae – Pondweed Family

Potamogeton pectinatus

Typhaceae - Cat-tail Family

Typha domingensis
T. latifolia

Dicotyledons

Amaranthaceae - Amaranth Family

Amaranthus albus
A. blitoides
A. californicus
A. fimbriatus

Anacardiaceae - Sumac Family

Rhus trilobata var. *anisophylla*

Apiaceae - Carrot Family

Apium graveolens
Berula erecta

Apiaceae - Carrot Family (Cont'd)

Cymopterus aboriginum
C. gilmanii
C. globosus
C. purpurascens
C. ripleyi
C. ripleyi var. *saniculoides* **
Daucus carota
Lomatium foeniculaceum ssp. *fimbriatum*
L. nevadense var. *nevadense*
L. scabrum
Pteryxia hendersonii

Apocynaceae - Dogbane Family

Amsonia tomentosa

Asclepiadaceae - Milkweed Family

Asclepias erosa
Cynanchum utahense

Asteraceae - Aster Family

Acamptopappus shockleyi
Achillea millefolium var. *lanulosa*
Acroptilon repens
Adenophyllum cooperi
Agoseris glauca var. *laciniata*
Ambrosia acanthicarpa
A. dumosa
A. eriocentra
Amphipappus fremontii var. *fremontii*
Anisocoma acaulis
Antennaria dimorpha
A. rosea
Artemisia bigelovii
A. dracunculus
A. ludoviciana
A. ludoviciana ssp. *incompta*
A. nova
Artemisia spinescens
A. tridentata ssp. *tridentata*
Atrichoseris platyphylla
Baccharis emoryi
Baileya multiradiata
B. pleniradiata
Balsamorhiza hookeri var. *neglecta*
Brickellia arguta
B. atractyloides
B. californica

Asteraceae - Aster Family (Cont'd)

Brickellia desertorum
B. incana
B. longifolia
B. longifolia var. *multiflora*
B. microphylla var. *scabra*
B. microphylla var. *watsonii*
B. oblongifolia var. *linifolia*
Calycoseris parryi
C. wrightii
Chaenactis carphoclinia
C. douglasii
C. fremontii
C. macrantha
C. stevioides
C. xantiana
Chaetadelphia wheeleri
Chrysothamnus gramineus
C. greenei
C. viscidiflorus ssp. *viscidiflorus* var. *stenophyllus*
C. viscidiflorus ssp. *puberulus*
C. viscidiflorus ssp. *viscidiflorus*
Cirsium neomexicanum
Conyza canadensis
Crepis intermedia
C. occidentalis ssp. *occidentalis*
C. runcinata ssp. *hallii*
Encelia virginensis var. *virginensis*
Enceliopsis nudicaulis var. *nudicaulis*
Ericameria cooperi
E. cuneatus
E. linearifolius
E. nanus
E. nauseosa
E. nauseosa ssp. *consimilis* var. *leiosperma*
E. nauseosa ssp. *nauseosa* var. *hololeuca*
E. paniculata
E. parryi var. *nevadensis*
E. teretifolia
E. watsonii
Erigeron aphanactis
E. breweri var. *porphyreticus*
E. concinnus var. *concinnus*
E. divergens
Eriophyllum pringlei
Geraea canescens
Glyptopleura marginata

Asteraceae - Aster Family (Cont'd)

Gnaphalium palustre
Grindelia squarrosa var. *serrulata*
Gutierrezia microcephala
G. sarothrae
Hazardia brickellioides
Hecastocleis shockleyi
Helianthus annuus
H. petiolaris ssp. *fallax*
H. petiolaris ssp. *petiolaris*
Heliomeris multiflora var. *nevadensis*
Heterotheca villosa var. *hispida*
Hulsea vestita ssp. *inyoensis*
Hymenoclea salsola
Hymenopappus filifolius var. *megacephalus*
Hymenoxys cooperi var. *cooperi*
Isocoma acradenius var. *eremophilus*
Iva nevadensis
Lactuca serriola
Leucelene ericoides
Lygodesmia dianthopsis
Machaeranthera canescens ssp. *canescens*
M. gooddingii
M. gracilis
Malacothrix coulteri
M. glabrata
M. sonchoides
Monoptilon bellidiforme
M. bellioides
Pectis papposa
Perityle megalocephala var. *intricata* **
P. megalocephala var. *megalocephala*
Petradoria pumila
Peucephyllum schottii
Pleurocoronis pluriseta
Porophyllum gracile
Prenanthella exigua
Psathyrotes annua
P. ramosissima
Pseudognaphalium stramineum
Psilostrophe cooperi
Rafinesquia neomexicana
Senecio integerrimus var. *exaltatus*
S. multilobatus
S. spartioides
Sonchus asper
Stephanomeria exigua ssp. *exigua*

Asteraceae - Aster Family (Cont'd)

S. parryi
S. pauciflora
S. spinosa
Stylocline micropoides
S. psilocarphoides
Syntrichopappus fremontii
Tetradymia axillaris var. *axillaris*
T. canescens
T. glabrata
Thymphylla pentachaeta var. *belenidium*
Townsendia scapigera
Uropappus linearifolia
Xanthium strumarium var. *canadense*
Xylorhiza tortifolia var. *imberbis*

Boraginaceae - Borage Family

Amsinckia tessellata
Cryptantha ambigua
C. angustifolia
C. barbigera
C. circumscissa
C. confertiflora
C. decipiens
C. dumetorum
C. flavoculata
C. gracilis
C. humilis
C. maritima
C. micrantha
C. nevadensis var. *nevadensis*
C. pterocarya
C. racemosa
C. recurvata
C. scoparia
C. utahensis
C. virginensis
C. watsonii
Lappula occidentalis var. *occidentalis*
Lithospermum ruderale
Pectocarya heterocarpa
P. platycarpa
P. recurvata
P. setosa
Plagiobothrys arizonicus
P. jonesii
P. kingii

Boraginaceae – Borage Family (Cont'd)

Tidestromia oblongifolia ssp. *oblongifolia*
Tiquilia canescens var. *canescens*
T. nuttallii
T. plicata

Brassicaceae - Mustard Family

Arabis dispar
A. glaucovalvula
A. holboellii var. *pinetorum*
A. inyoensis
A. pendulina
A. perennans
A. pulchra var. *gracilis*
A. pulchra var. *munciensis*
A. shockleyi
Brassica geniculata
Caulanthus cooperi
C. crassicaulis var. *glaber*
C. pilosus
Descurainia pinnata ssp. *glabra*
D. pinnata ssp. *halictorum*
D. sophia
Draba cuneifolia var. *cuneifolia*
D. cuneifolia var. *integrifolia*
Guillenia lasiophylla
Hirschfeldia incana
Lepidium flavum var. *flavum*
L. fremontii
L. lasiocarpum
L. montanum var. *canescens*
L. perfoliatum
Lesquerella kingii ssp. *kingii*
L. ludoviciana
Malcolmia africana
Physaria chambersii
Sibara rosulata
Sisymbrium altissimum
S. irio
Stanleya elata
S. pinnata var. pinnata
Streptanthella longirostris
Streptanthus cordatus var. *cordatus*
Thelypodium laxiflorum
Thysanocarpus curvipes
T. laciniatus

Buddlejaceae - Butterfly-bush Family

Buddleja utahensis

Cactaceae - Cactus Family

Echinocactus polycephalus
Echinocereus engelmannii
E. engelmannii var. *armatus*
E. engelmannii var. *chysocentrus*
E. engelmannii var. *engelmannii*
E. triglochidiatus var. *melanacanthus*
Escobaria vivipara var. *deserti*
E. vivipara var. *rosea*
Mammillaria tetrancistra
Opuntia basilaris var. *basilaris*
O. echinocarpa var. *echinocarpa*
O. erinacea var. *erinacea*
O. erinacea var. *ursina*
O. polyacantha var. *rufispina*
O. pulchella
O. ramosissima
Sclerocactus polyancistrus

Campanulaceae - Bellflower Family

Nemacladus glanduliferus var. *orientalis*
N. rubescens
N. sigmoideus

Capparaceae - Caper Family

Cleome lutea

Caprifoliaceae - Honeysuckle Family

Symphoricarpos longiflorus
S. rotundifolius var. *parishii*

Caryophyllaceae - Pink Family

Arenaria congesta var. *subcongesta*
A. kingii ssp. *compacta*
A. macradenia
A. macradenia ssp. *ferrisiae*
A. macradenia ssp. *macradenia* var. *macradenia*
Scopulophila rixfordii
Silene verecunda ssp. *andersonii*

Celastraceae - Staff-tree Family

Mortonia utahensis

Chenopodiaceae - Goosefoot Family

Atriplex argentea ssp. *expansa*
A. canescens var. *canescens*
A. confertifolia

Chenopodiaceae – Goosefoot Family (Cont'd)

Atriplex elegans var. *fasciculata*
A. hymenelytra
A. lentiformis ssp. *lentiformis*
A. polycarpa
Bassia hyssopifolia
Chenopodium album
C. album var. *missouriense*
C. atrovirens
C. berlandieri var. *sinuatum*
C. berlandieri var. *zschackei*
C. fremontii
C. incanum
C. leptophyllum
C. pratericola
C. simplex
C. strictum ssp. *glaucophyllum*
Grayia spinosa
Halogeton glomeratus
Kochia americana
K. iranica
K. scoparia
Krascheninnikovia lanata
Monolepis spathulata
Salsola kali ssp. *tragus*
S. paulsenii
Suaeda moquinii

Convolvulaceae – Morning-glory Family

Convolvulus arvensis

Crossosomataceae – Crossosoma Family

Glossopetalon spinescens var. *aridum*

Cuscutaceae - Dodder Family

Cuscuta denticulata
C. denticulata var. *vetchii*

Euphorbiaceae - Spurge Family

Chamaesyce albomarginata
C. fendleri
C. micromera
C. parishii
C. serpyllifolia ssp. *serpyllifolia*
C. setiloba

Euphorbiaceae - Spurge Family

Stillingia spinulosa

Fabaceae - Pea Family

Astragalus acutirostris
A. beatleyae **
A. beckwithii
A. calycosus var. *calycosus*
A. casei
A. didymocarpus var. *dispermus*
A. funereus **
A. layneae
A. lentiginosus var. *fremontii*
A. lentiginosus var. *micans*
A. lentiginosus var. *variabilis*
A. minthorniae var. *villosus*
A. mohavensis var. *mohavensis*
A. newberryi
A. newberryi var. *castoreus*
A. newberryi var. *newberryi*
A. nyensis
A. oophorus var. *clokeyanus* **
A. purshii var. *lectulus*
A. purshii var. *tinctus*
A. tidestromii
Dalea mollissima
D. searlsiae
Lathyrus hitchcockianus
Lotus humistratus
Lupinus argenteus ssp. *artenteus* var. *laxiflorus*
L. aridus
L. brevicaulis
L. caudatus
L. concinnus ssp. *orcuttii*
L. flavoculatus
L. holmgrenanus
L. microcarpus
L. palmeri
L. shockleyi
L. subvexus
L. uncialis
Medicago sativa
Melilotus indicus
M. officinalis
Peteria thompsonae
Prosopis glandulosa var. *torreyana*
Psorothamnus fremontii var. *fremontii*
P. polydenius
Trifolium andersonii

Fagaceae - Beech Family

Quercus gambelii

Gentianaceae - Gentian Family

Frasera albomarginata
F. pahutensis **

Geraniaceae - Geranium Family

Erodium cicutarium

Grossulariaceae - Currant Family

Ribes cereum var. *cereum*
R. velutinum var. *velutinum*

Hydrangeaceae - Hydrangea Family

Fendlerella utahensis

Hydrophyllaceae - Waterleaf Family

Eucrypta micrantha
Nama aretioides
N. demissum var. *demissum*
N. densum
N. depressum
N. pusillum
Phacelia affinis
P. ambigua
P. beatleyae **
P. bicolor
P. calthifolia
P. crenulata var. *crenulata*
P. cryptantha
P. curvipes
P. distans
P. fremontii
P. lemmonii
P. mustelina
P. parishii **
P. pedicellata
P. peirsoniana
P. rotundifolia
P. saxicola
P. tetramera
P. vallis-mortae var. *vallis-mortae*
Tricardia watsonii

Krameriaceae - Krameria Family

Krameria erecta

Lamiaceae - Mint Family

Hedeoma nanum ssp. *californicum*
Marrubium vulgare

Lamiaceae - Mint Family (Cont'd)

Monardella glauca
Salazaria mexicana
Salvia columbariae var. *columbariae*
S. dorii ssp. *dorrii* var. *dorrii*

Linaceae - Flax Family

Linum lewisii

Loasaceae - Losa Family

Eucnide urens
Mentzelia albicaulis
M. congesta
M. montana
M. nitens
M. obscura
M. oreophila
M. reflexa
M. veatchiana
Petalonyx nitidus
P. thurberi ssp. *thurberi*

Malvaceae - Mallow Family

Eremalche exilis
E. rotundifolia
Malva parviflora
Sphaeralcea ambigua ssp. *ambigua*
S. ambigua ssp. *monticola*
S. ambiguua var. *rugosa*
S. emoryi
S. grossulariaefolia ssp. *pedata*
S. parvifolia

Molluginaceae - Carpet-weed Family

Mollugo cerviana

Nyctaginaceae - Four o'clock Family

Abronia elliptica
A. turbinata
Allionia incarnata
Mirabilis bigelovii
M. bigelovii var. *bigelovii*
M. multiflora var. *glandulosa*
M. pudica
Oxybaphus comatus
Selinocarpus nevadensis
Senecio flaccidus var. *douglasii*

Oleaceae - Olive Family

Forestiera pubescens var. *pubescens*
Fraxinus anomala
F. velutina
Menodora spinescens

Onagraceae - Evening Primrose Family

Camissonia boothii ssp. *condensata*
C. boothii ssp. *intermedia*
C. brevipes ssp. *brevipes*
C. brevipes ssp. *pallidula*
C. californica
C. chamaenerioides
C. claviformis ssp. *integrior*
C. heterochroma
C. kernensis ssp. *gilmanii*
C. megalantha **
C. munzii
C. parvula
C. pterosperma
C. pusilla
C. refracta
C. walkeri ssp. *tortilis*
Epilobium ciliatum
E. glaberrimum
Gaura coccinea
Gayophytum decipiens
G. diffusum ssp. *parviflorum*
G. racemosum
G. ramosissimum
Oenothera caespitosa ssp. *marginata*
O. californica spp. avita
O. deltoides ssp. *deltoides*
O. pallida ssp. *pallida*
O. primiveris

Orobanchaceae - Broom-rape Family

Orobanche cooperi
O. corymbosa
O. fasciculata

Papaveraceae - Poppy Family

Arctomecon merriamii **
Argemone corymbosa
A. munita ssp. *rotundata*
Eschscholzia glyptosperma
E. minutiflora
E. multiflora ssp. *covillei*

Plantaginaceae - Plantain Family

Plantago ovata
P. patagonica

Polemoniaceae - Phlox Family

Collomia tenella
Eriastrum eremicum
E. sparsiflorum
E. wilcoxii
Gilia aliquanta ssp. *breviloba*
G. brecciarum ssp. *brecciarum*
G. campanulata
G. cana ssp. *speciformis*
G. cana ssp. *triceps*
G. clokeyi
G. filiformis
G. hutchinsifolia
G. inconspicua
G. latifolia
G. leptomeria
G. malior
G. modocensis
G. nyensis
G. ophthalmoides
G. ripleyi
G. scopulorum
G. sinuata
G. stellata
G. transmontana
Ipomopsis congesta
I. depressa
I. polycladon
Langloisia setosissima
L. setossima ssp. *punctata*
Leptodactylon pungens
Linanthus arenicola
L. bigelovii
L. demissus
L. dichotomus
L. jonesii
L. nuttallii ssp. *nuttallii*
L. septentrionalis
Loeseliastrum schottii
Navarretia breweri
Phlox gracilis ssp. *humilis*
P. hoodii ssp. *lanata*
P. stansburyi

Polygalaceae - Milkwort Family

Polygala heterorhyncha
P. subspinosa

Polygonaceae - Buckwheat Family

Centrostegia thurberi
Chorizanthe brevicornu var. *brevicornu*
C. brevicornu var. *spathulata*
C. rigida
C. watsonii
Eriogonum baileyi var. *baileyi*
E. brachyanthum
E. brachypodum
E. caespitosum
E. cernuum var. *cernuum*
E. cernuum var. *viminale*
E. concinnum
E. deflexum
E. deflexum var. *baratum*
E. deflexum var. *deflexum*
E. deflexum var. *nevadense*
E. esmeraldense var. *esmeraldense*
E. fasciculatum var. *polifolium*
E. glandulosum
E. heermannii var. *argense*
E. heermannii var. *heermannii*
E. heermannii var. *sulcatum*
E. hookeri
E. howellianum
E. inflatum
E. insigne
E. maculatum
E. microthecum var. *lapidicola*
E. microthecum var. *simpsonii*
E. nidularium
E. nummulare
E. nutans var. *nutans*
E. ovalifolium var. *ovalifolium*
E. palmerianum
E. pusillum
E. racemosum
E. reniforme
E. saxatile
E. thomasii
E. trichopes
E. umbellatum
E. umbellatum var. *dichrocephalum*
E. umbellatum var. *subaridum*

Polygonaceae - Buckwheat Family (Cont'd)

E. umbellatum var. *vernum*
E. umbellatum var. *versicolor*
E. wrightii var. *subscaposum*
Oxytheca perfoliata
Polygonum argyrocoleon
P. aviculare
P. douglasii ssp. *johnstonii*
P. pensylvanicum
Rumex crispus
R. salicifolius

Portulacaceae - Purslane Family

Cistanthe monandra
C. parryi var. *nevadense*
Claytonia perfoliata ssp. *perfoliata*
Lewisia rediviva var. *minor*

Ranunculaceae - Buttercup Family

Anemone tuberosa
Aquilegia formosa var. *formosa*
Delphinium andersonii
D. parishii ssp. *parishii*
Ranunculus andersonii

Rhamnaceae - Buckthorn Family

Ceanothus greggii ssp. *vestitus*

Rosaceae - Rose Family

Amelanchier pallida
A. utahensis
Cercocarpus intricatus
C. ledifolius var. *ledifolius*
Chamaebatiaria millefolium
Coleogyne ramosissima
Fallugia paradoxa
Holodiscus discolor
Ivesia arizonica var. *saxosa*
I. sabulosa
Peraphyllum ramosissimum
P. caespitosum
Potentilla biennis
Prunus fasciculata
Purshia glandulosa
P. stansburiana
P. tridentata
Rosa woodsii

Rubiaceae - Madder Family

Galium aparine
G. bifolium
G. hilendiae ssp. *hilendiae*
G. hilendiae ssp. *kingstonense* **
G. magnifolium
G. stellatum

Rutaceae - Rue Family

Thamnosma montana

Salicaceae - Willow Family

Populus fremontii ssp. *fremontii*
Salix exigua
S. gooddingii

Saxifragaceae - Saxifrag Family

Lithophragma tenellum

Scrophulariaceae - Figwort Family

Castilleja applegatei
C. applegatei ssp. *martinii*
C. linariaefolia
Collinsia parviflora
Keckiella rothrockii ssp. *rothrockii*
Mimetanthe pilosus
M. bigelovii var. *bigelovii*
M. densus
M. guttatus
M. montioides
M. rubellus
M. spissus
M. suksdorfii
Mohavea breviflora
Neogaerrhinum filipes
Penstemon albomarginatus **
P. angustifolius var. *venosus*
P. floridus var. *austinii*
P. fruticiformis ssp. *amargosae* **
P. humilis ssp. *humilis*

Scrophulariaceae - Figwort Family (Cont'd)

P. pahutensis **
Penstemon palmeri
P. petiolatus
P. rostriflorus
P. thurberi
Saircocarpus kingii
Scrophularia desertorum
Veronica americana
V. anagallis-aquatica
V. peregrina ssp. *xalapensis*

Solanaceae - Potato Family

Datura wrightii
Lycium andersonii
L. pallidum var. *oligospermum*
L. shockleyi
Nicotiana attenuata
N. trigonophylla var. *trigonophylla*
Physalis crassifolia
Solanum americanum

Tamaricaceae - Tamarisk Family

Tamarix ramosissima

Ulmaceae - Elm Family

Ulmus minor
U. parvifolia

Verbenaceae - Verbena Family

Verbena bracteata

Viscaceae - Christmas Mistletoe Family

Arceuthobium divaricatum
Phoradendron juniperinum

Zannichelliaceae - Horned pondweed Family

Zannichellia palustris

Zygophyllaceae - Creosote-bush Family

Larrea tridentata
Tribulus terrestris

DIVISION PTERIDOPHYTA (FERNS)

Pteridaceae - Maidenhair Fern Family

Argyrochosma jonesii
Cheilanthes covillei
C. parryi
Pellaea mucronata ssp. *mucronata*
P. truncata
Pentagama triangularis
P. triangularis ssp. *triangularis*

** Designates a species considered important because of federal protective status or concern.

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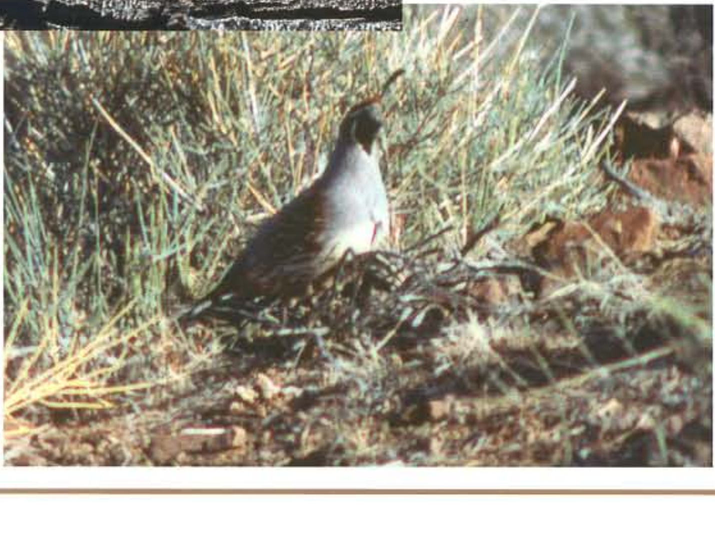
SPECIES LIST OF FAUNA OF THE NEVADA TEST SITE

SPECIES LIST OF FAUNA OF THE NEVADA TEST SITE

This section includes all animal species presently known to occur on the NTS. It was developed from the following sources:

Invertebrates	Fishes	Reptiles	Birds	Mammals
10-14, 16, 23-25, 28, 32, 60, 61, 97-99, 100, 129, 130, 140-143, 153-155, 201, 236, 241, 283, 363, 366, 381, 473, 474, 498, 510, 686, 700-704, 820	121, 139, 498	28, 99, 115, 121, 447, 498, 705-708, 710	28, 99, 121, 139, 286, 498	28, 99, 121, 367, 368, 498

The listing of vertebrates are not presented in taxonomic order. Instead, phyla are listed alphabetically. Then classes, orders, families, and genus/species within a family are each presented in alphabetical order. Names of taxonomic authorities were not included, but they can be found in the original source material cited above. Common names have been included for all the vertebrates since they are used so frequently and are generally unique. All scientific and common names were taken from the following sources access on May 14, 2001:

http://www.itis.usda.gov/index.htmln - for Annelida, Mollusca, Crustacea, Myriapoda, Actinopterygii, Mammalia, Reptilia
http://www.aou.org/aou/birdlist.html - for Aves
http://www.nearctica.com/nomina/main.html - for Hexapoda
http://www.nematode.unl.edu - for Nemata
http://128.187.39.87/^insects/index_ie.htm - for Acarina
http://wrbu.si.edu/www/stockwell/classification/classification.html#luridae - for Scorpions
http://research.amnh.org/entomology/spiders/catalog81-87/intro3.html - for Spiders

Specimens have been deposited in several museums, but the most complete collection is housed at Brigham Young University [29].

INVERTEBRATES

PHYLUM ANNELIDA (SEGMENTED WORMS)

Order Haplotaxida - Aquatic Earthworms

Family Naididae

Unknown sp.

PHYLUM ARTHROPODA (ARTHROPODS)

Subphylum Chelicerata

Order Acarina - Ticks and Mites

Family Ameroseiidae

Kleemania sp.

Family Argasidae

Argas persicus
Ornithodoros kelleyi
O. parkeri
O. sparnus
O. talaje
Otobius lagphilus

Family Belbidae

Belba sp.
Spinibdella sp.

Family Caligonellidae

Molothiognathus sp. *
Neothrognathus sp. *

Family Cosmocthoniidae

Cosmochthoniidae sp.

Family Ctenacaridae

Aphelacarus acarinus *

Family Cunaxidae

Cunaxa sp.
Cunaxoides sp.

Family Dermanyssidae

Brevisterna utahensis *
Dermanyssus becki
Hirstionyssus bisetosus *
H. carnifix *
H. hill *
H. neotomae *
H. triacanthus

Family Dermanyssidae (Cont'd)

Ornithonyssus aridus *
Steatonyssus antrozoi *

Family Eremaeidae

Eremaeus sp. *

Family Erthraeidae

Hauptmannia sp. *
Pollux sp. *

Family Erythraeidae

Caeculisoma sp. *

Family Gymnodamaeidae

Joshuella striata *

Family Haemogamasidae

Haemogamasus pontiger
Ischyropoda armatus

Family Ixodidae

Dermacentor albipictus
D. parumapertus
Haemaphysalis leporispalustris
Ixodes angustus
I. kingi
I. ochotonae
I. pacificus
I. sculptus
I. spinipalpus

Family Ixodorhynchidae

Ixodorhynchus sp.

Family Laelaptidae

Androlaelaps leviculus
Eubrachylaelaps circularis

Family Laelaptidae (Cont'd)

Eubrachylaelaps debilis
E. hollisteri
Haemolaelaps sp.
H. casalis
H. glasgowi
Hypoaspis leviculus

Family Linotetranidae

Linotetrans sp. *

Family Listrophoridae

Listrophorus dipodominus

Family Myobiidae

Lavoimyobia hughesi *

Family Nanorchestidae

Spelorchestes sp. *

Family Neophyllobiidae

Rhinonyssidae sp. *

Family Oribatulidae

Moltoribates sp.

Family Passalozetidae

Passalozetes sp.

Family Pterygosomidae

Geckobiella texana
Hirstiella sp.

Family Teneriffiidae

Tarsolarkus sp.
Tarsotomus sp.

Family Trombiculidae

Euschoengastia sp.
E. cordiremus
E. criceticola
E. decipiens
E. fasolla
E. lacerta
E. lanei
E. obesa
E. radfordi
E. utahensis
Leuwenhoekia americana
Odontacarus arizonensis
O. chiapansis
O. hirsutus
O. linsdalei
O. micheneri
Pseudoschongastia sp. *
Sascarus sp.
Trombicula 4 spp.
T. arenicola
T. belkini
T. jessiemae
T. panamensis
T. sola *
Whartonia perplexa
W. whartonia *

Family Trombidiidae

Allothrombium sp. *

Family Tuckerellidae

Tuckerella coleogynis

Order Araneae - Spiders

Family Agelenidae

Agelenopsis aperta
Calilena restricta

Family Anyphaenidae

Anyphaena sp.

Family Araneidae

Metepeira gosoga

Family Caponiidae

Orthonops gertschi
Tarsonops sp.

Family Clubionidae

Neoanagraphis chamberlini
N. pearcei

Family Corinnidae

Castianeira descripta
Corinna bicalcarata

Family Cyrtaucheniidae

Aptostichus stanfordianus

Family Dictynidae

Cicurina utahana
Dictyna calcarata
D. personata
D. reticulata
D. tucsona
Mallos mians
M. pallidus

Family Diguetidae

Diguetia canities
D. signata

Family Filistatidae

Kukulcania utahana

Family Gnaphosidae

Callilepis sp.
Cesonia classica
Drassodes saccatus
Drassyllus fractus
D. insularis
D. lamprus
Gnaphosa californica
G. hirsutipes
Haplodrassus eunis
Herpyllus hesperolus
Micaria gosiuta
Nodocion utus
Scopoides naturalisticus
Zelotes monachus
Z. nannodes
Z. puritanus

Family Homalonychidae

Homalonychus theologus

Family Linyphiidae

Ceraticelus nesiotes
Disembolus stridulans
Erigone dentosa
M. fillmorana
M. fratrella
Spirembolus sp.
Tapinocyba sp.
Tennesseellum formica

Family Liocranidae

Piabuna nanna
Phrurotimpus sp.

Family Lycosidae

Alopecosa kochi
Geolycosa rafaelana
Pardosa ramulosa
Schizocosa sp.

Family Mimetidae

Reo eutypus

Family Miturgidae

Syspira eclectica

Family Oxyopidae

Oxyopes tridens

Family Philodromidae

Apollophanes texanus
Ebo dispar
E. merkeli
E. mexicanus
Philodromus histrio
P. infuscatus

Family Pholcidae

Physocyclus tanneri
Psilochorus papago
P. utahensis

Family Plectreuridae

Kibramoa paiuta
Plectreurys tristis

Family Salticidae

Habronattus agilis
H. brunneus
H. hirsutus
H. oregonensis
Metacyrba arizonensis
M. taeniola
Metaphidippus sp.
Peckhamia sp.
Pellenes limatus
Phidippus insolens
P. johnsoni
P. octopunctatus
P. workmani
P. californicus

Family Sicariidae

Loxosceles deserta

Family Sparassidae

Olios fasciculatus

Family Tetragnathidae

Tetragnatha laboriosa

Family Theraphosidae

Aphonopelma steindachneri

Family Theridiidae

Achaearanea sp.
Enoplognatha joshua
Euryopis scriptipes
E. spinigera
Latrodectus hesperus
L. mactans
Steatoda fulva
S. pulchra
S. washona
Theridion sp.

Family Thomisidae

Misumenops deserti
M. rothi
Xysticus californicus
X. iviei
X. lassanus

Family Uloboridae

Uloborus diversus

Order Opiliones - Harvestmen

Family Phalangiidae

Eurybunus riversi *
Globipes spinulatus *
Leiobunum townsendi *

Order Scorpiones - Scorpions

Family Iuridae

Anuroctonus phaiodactylus
Hadrurus arizonensis
H. hirsutus
H. spadix

Family Superstitionidae

Superstitionia donensis

Family Vaejovidae

Paruroctonus becki
Paruroctonus boreas
Serradigitus wupatkiensis
Vaejovis confusus
V. hirsuticauda
V. spinigeris

Order Solpugida – Sun Spiders

Family Ammotrechidae

Ammontrechula dolabra *
A. lacuna *
A. pilosa *
Branchia potens *

Family Eremobatidae

Chanbria sp. *
Eremobates ctenidiellus *
E. mormonus *
E. scopulatus *
E. similis *
E. vicinus *

Family Eremobatidae (Cont'd)

E. zinni *
Eremorhax pulcher *
E. titania *
Hemerotrecha branchi *
H. californica *
Hemerotrecha denticulata *
H. fruitana *
H. jacintoana *
H. proxima *
H. serrata *
Horribates sp. *

Family Eremobatidae (Cont'd)

Therobates arcus *

T. attritus *

T. bidepressus *

T. branchi *

Family Eremobatidae (Cont'd)

Therobates cameronensis *

T. flexacus *

T. nudus *

T. plicatus *

Subphylum Crustacea

Order Anostraca - Fairy Shrimp

Family Branchinectidae

Branchinecta gigas

B. mackini

Family Thamnocephalidae

Thamnocephalus platyurus

Order Cladocera - Water Fleas

Family Daphniidae

Daphnia sp.

Order Conchostraca - Clam Shrimp

Family Limnadiidae

Eulimnadia antlei

Order Copepoda - Copepods

Family Cyclopidae

Cyclops sp.

Family Diaptomidae

Diaptomus sp.

Order Decapoda - Decapods

Family Cambaridae

Unknown sp.

Order Isopoda - Isopods

Family Armadillidae

Venezillo arizonicus

Family Porcellionidae

Porcellio laevis

Order Notostraca - Tadpole Shrimp

Family Lepiduridae

Triops longicaudatus

Order Ostracoda - Seed Shrimp

Family Cypridae

Herpetocypris fretensis

Family Darwinuliidae

Darwinula stevensoni

Subphylum Hexapoda

Class Insecta - Insects

Order Blattodea - Cockroaches

Family Polyphagidae

Arenivaga apacha
A. erractica
Eremoblatta subdiaphana

Order Coleoptera – Beetles

Family Alleculidae

Hymenorus prolixus

Family Anthribidae

Trigonorhinus irregularis

Family Attelabidae

Auletobius sp.
A. humeralis

Family Brentidae

Apion albidulum
A. varicorne

Family Buprestidae

Acmaeodera sp.
A. diffusa
A. immaculata
A. lanata
A. purshiae *
Agrilus felix
Agrilus pubifrons
Anthaxia deleta
Chrysobothris arizonica
C. cuprascens
C. platti
Hippomelas near obliterata
Melanophila piniedulis
Oxypteris consputa

Family Carabidae

Calosoma sp.
Harpalus sp.
Lebia sp.
Pterostichus sp.
Rhadine jejunus
R. myrmecodes

Family Cerambycidae

Moneilema gigas
M. semipunctatum
Prionus californicus

Family Chrysomelidae

Chaetocnema sp.
Chlamisus memnonia *
Diplocapsis sp.
Monoxia sp.
Octatoma sp.
Pachybrachis sp.
Trirhabda sp.

Family Cicindelidae

Cicindela sp.

Family Cleridae

Aulicus reichei *
Caccodes quadrimaculatus
Cymatodera fuchsii
C. latefascia
C. oblita *
C. uniformis
Phyllobaenus pygmaea
P. subfasciata
Priocera inornata
Trichodes ornatus

Family Coccinellidae

Hippodamia apicalis
H. convergens
H. parenthesis
H. quinquesignata
Hyperaspis pleuralis
H. quadrivittata
H. taeniata

Family Coccinellidae (Cont'd)

Scymnus aridus
S. pallens

Family Curculionidae

Amotus setulosus
Anthonomus cycliferus
A. haematopus
A. hirtus
A. inermis
A near *juniperinus*
A. ochreopilosus
A. ornatulus
A. peninsularis
A. sphaeralciae
A. tenius
Apleurus angularis
Apleurus porosus
Aragnomus sp.
A. hispidulus
A. hispidus
Auleutes sp.
Brachyogmus ornatus
Ceutorhynchus adjunctus
Cimbocera buchanani
C. cazieri
Cleonidius poricollis
C. quadrilineatus
Crocidema californica
Cryptolepidus aridus
Cryptolepidus leechi
C. nevadicus
Cylindrocopturus sp.
Eucyllus echinus
E. nevadensis
E. unicolor
E. vagans
Eupagoderes geminatus
E. geminatus
Lepidophorus sp.
Magdalis lecontei
Miloderes mercuryensis
Minyomerus sp.
Myrmex lineatus
Onychobarius near depressa
O. mystica
Ophryastes varius

Family Curculionidae (Cont'd)

Orimodema protracta
O. sordidus
Paracimbocera artemisiae
P. atra
Promecotarsus densus
Sirocalodes tescorum
Smicronyx sp.
S. imbricatus
Thricolepis inornata
Tychius prolixus
T. setosa
Yuccaborus frontalis
Zascelis irrorata

Family Elateridae

Horistonotus sp.

Family Elmidae

Elmira sp. *

Family Gyrinidae

Gyrinidae sp. *

Family Histeridae

Saprinus sp.

Family Leiodidae

Ptomaphagus sp.

Family Meloidae

Cysteodemus armatus
Lytta sp.
Saprinus armatus

Family Melyridae

Asydates sp.
Attalus futilis
Collops punctulatus
Eutrichopleurus concinnus
Listrus sp. *
Malachius sp.
Melyrodes sp.
Trichochrous varius

Family Nitidulidae

Carpophilus hemipterus
Cybocephalus californicus

Family Ochodaeidae

Ochodaeus sparsus
O. sparsus

Family Phalacridae

Phalacrus sp.

Family Scarabaeidae

Aphodius sp.
A. fucosus
A. militaris
A. near *talpoidesi*
A. nevadensis
Bothynus sp.
Chnaunanthus flavipennis
Cyclocephala longula
Diplotaxis deserta
D. haydenii
D. incuria
D. insignis
D. moerens
D. pacata
D. subangulata
Paracotalpa granicollis
Phyllophaga sp.
P. sociatus
Serica alternata
S. perigonia

Family Scolytidae

Ips confusus

Family Sulvanidae

Oryzaephilus surinamensis

Family Tenebrionidae

Alaephus nevadensis
Anemia californica
Anepsius near brunneus
Asidina semilaevis
A. semilaevis
Auchmobius subboreus
Blapstinus lecontei
B. vandykei
Bothrotes sp.
Centrioptera muricata
Chilometopon abnorme
Coelocnemis punctata
Coniontellus argutus
C. armata
Coniontis lassenica
Craniotus blaisdelli
Cryptoglossa verrucosus
Discodemus near *knausi*
Edrotes ventricosus
Eleodes armata
E. brunnipes

Family Tenebrionidae (Cont'd)

Eleodes near *californica*
E. carbonaria
E. concinna
E. dissimilis
E. extricata
E. grandicollis
E. hispilabris
E. longicollis
E. longipilosa
E. nevadensis
E. nigrina
E. obscura
E. omissa
E. pimelioides
E. striatipennis
E. tenebrosa
Embaphion elongatum
Eschatomoxys wagneri
Eupsophulus castaneus
Eusattus difficilis
E. dilatatus
E. dubius
E. elongatum
E. muricatus
Euschides luctatus
Helops sp.
H. attenuatus
Hylocrinus laborans
Lobometopon sp.
Metopoloba bifossiceps
Metoponium abnorme
M. near *convexicolle*
Notibius substriatus
N. sulcicollis
Pelecyphorus actuosus
P. pantex
Philolithus pantex
Steriphanus lubricans
Trichiasida acerba
Triorophus laevis
Trogloderus costatus

Family Unknown

Neocercopedius sp. *

Family Zopheridae

Zopherus uteanus

Order Diptera - True Flies

Family Asilidae

Efferia sp.
E. benedicti
E. etaminea *

Family Bombyliidae

Anastoechus hessei
A. melanohalteralis
Anthrax albofasciatus
A. limatulus
A. nidicola
A. oedipus
A. seriepunctata
Aphoebantus abnormis
A. altercinctus
A. arenicola
A. argentifrons *
A. borealis
A. brevistylus
A. desertus
A. eremicola
A. fumosus
A. interruptus
A. marcidus
A. marginatus
A. mormon
A. mus
A. parkeri
A. pavidus
A. peodes
A. scalaris
A. scriptus
A. tardus
A. timberlakei
A. transitus
A. ursula
A. varius
A. vasatus
A. vittatus
A. vulpecula
Apolysis ater
A. cincturus
A. distinctus
A. fasciolus
A. mus

Family Bombyliidae (Cont'd)

Aphoebantus pulcher
A. pullatus
Astrophanes adonis
Bombylius lancifer
Conophorus fenestrata
Desmatoneura argentifrons
Dipalta serpentina
Epacmus connectens
E. labiosus
E. litus
E. pulvereus
Eucessia rubens
Exepacmus johnsoni
Exprosopa arenicola
Exprosopa caliptera
E. divisa
E. dorcadion
E. doris
E. sharonae
E. utahensis
Geminaria canalis
G. pellucida
Geron argutus
Heterostylum robustus
H. sackeni *
H. vierecki *
Lepidanthrax agrestis
L. angulus
L. hyalinipennis
Lordotus abdominalis
L. albidus
L. apicula
L. gibbus
L. junceus
L. luteolus
L. melanosus *
L. nigriventrus *
L. perplexus
L. pulchrissimus
L. singulatus *
L. sororculus
L. striatus
Mythicomyia sp.
Oligodranes dolorosus

Family Bombyliidae (Cont'd)

Pantarbes capito
P. pusio
P. willistoni
Paraconsors humeralis
Paracosmus insolens
P. morrisoni
Poecilanthrax alpha
P. apache
P. californicus
P. moffitti
P. poecilogaster
P. willistonii
Toxophora pellucida
T. vasta
T. virgata
Villa aenea
V. arizonensis *
V. atrata *
V. cautor
V. crocina *

Family Bombyliidae (Cont'd)

V. cypris *
V. junctura *
V. lepidota *
V. mira *
V. morio *
V. scitula *
V. sinuosa *
V. supina
V. utahensis *

Family Cecidomyiidae

Asphondylia sp.

Family Chironomidae

Chironomus sp.

Family Culicidae

Culiseta sp.

Family Mydidae

Pseudonomoneura californica

Family Syrphidae

Pyritis sp.
Unknown sp.

Order Embioptera - Webspinners

Family Anisembiidae

Dactylocerca rubra

Order Ephemeroptera - Mayflies

Family Baetidae

Callibaetis sp.

Family Ephemeridae

Unknown sp.

Order Heteroptera - True Bugs

Family Berytidae

Jalysus wickhami
Neides muticus
Pronotacantha annulata

Family Cynidae

Pangaeus congruus

Family Lygaeidae

Geocoris pallens
Nysius ericae *

Family Miridae

Atomoscelis modesta
Atractotomus balli
A. pallens
A. prospidis
Beamerella balius
Beckocoris laticephalus
Bolteria juniperi
B. speciosus
Brachyceratocoris nevadensis

Family Miridae (Cont'd)

Brooksetta chelifer
B. nevadensis
Ceratocapsus fusiformis
C. nevadensis
C. nigrocuneatus
Chlamydatus associatus
C. becki
Chlamydatus monilipes
Clivinema sp.
Coquillettia albella
C. luteiclava
C. virescens
Daleapidea albescens
D. daleae
Deraeocoris bakeri
D. brevis
D. bullatus
D. juniperi
D. merinoi
D. nevadensis
D. pinicola
D. schwarzii
Dichaetocoris peregrinus
Dichrooscytus apicalis
D. flavivenosus
D. irroratus
D. junipericola
D. pinicola
Dicyphus hesperus
D. ribesi
Europiella albipubescens
E. decolor
E. grayiae
E. lycii
E. nigricornis
E. nigrofemoratus
E. punctipes
Europiella sparsa
E. stigmosus
E. unipuncta
Hadronema picta
H. uhleri
Hoplomachidea consors
Largidea nevadensis
Lopidea bullata
L. fuscosa

Family Miridae (Cont'd)

Lopidea picta
L. scutata
L. ute
Lygus desertus
L. elisus
L. hesperus
Macrotylus infuscatus
M. salviae
Melanotrichus albocostatus
M. atriplicis
M. coagulatus
M. eurotiae
M. knighti
M. pallens
M. stanleyaea
M. symphoricarpi
Merinocapsus ephedrae
M. pallipes
Microphylellus symphoricarpi
Nevadocoris becki
N. bullatus
N. pallidus
Oncotylus guttulatus
Parthenicus accumulus
P. atriplicis
P. becki
P. brevicornis
P. condensus
P. covilleae
P. cuneotinctus
P. desertus
P. furcatus
P. incurvus
P. merinoi
P. miniopunctatus
P. nevadensis
P. nigripunctus
Parthenicus pictus
P. pilipes
P. pinicola
P. rubrosignatus
P. rufusculus
P. sabulosus
P. tenuis
P. trispinosus
P. utahensis

Family Miridae (Cont'd)

Phoenicocoris pini
Phyllopidea hirta
P. picta
Phymatopsallus prosopidis
P. ribesi
Phytocoris albidopictus
P. albidosquamus
P. becki
P. breviatus
P. candidus
P. carnosulus
P. consors
P. cuneotinctus
P. decurvatus
P. deserticola
P. geniculatus
P. hirsuticus
P. inops
P. juniperànus
P. longihirtus
P. mellarius
P. minituberculatus
P. nigrolineatus
P. plenus
P. pulchellus
P. pulchricollis
P. ramosus
P. relativus
P. reticulatus
P. rostratus
P. squamosus
P. stitti
P. strigosus
P. tenuis
P. tricinctipes
P. vanduzeei
P. ventralis
Pilophorus clavicornis
P. tibialis
Plagiognathus salviae
Platylygus vanduzeei
Polymerus relativus
Psallus atriplicis
P. purshiae
Pseudatomoscelis seriatus
Pseudopsallus daleae

Family Miridae (Cont'd)

Pseudopsallus plagiatus
P. puberus
P. repertus
Rhinacloa forticornis
Semium subglaber
Sericophanes nevadensis
Slaterocoris sp.
S. croceipes
S. longipennis
S. rubrofemoratus
Spanagonicus albofasciata
Stenodema virens *
Stittocapsus franseriae
Trigonotylus americanus

Family Nabidae

Nabis sp.

Family Notonectidae

Unknown sp.

Family Pentatomidae

Banasa euchlora
Brochymena sulcata
Chlorochroa sayi
Dendrocoris sp.
D. contaminatus
Prionosoma podopioides
Tepa rugulosa
Thyanta pallidovirens

Family Phymatidae

Macrocephalus sp.

Family Reduviidae

Reduvius sp.
Zelus sp.

Family Rhopalidae

Arhyssus sp.
A. lateralis
Harmostes angustatus
H. fraterculus
H. reflexulus
Liorhyssus hyalinus

Family Tingidae

Corythucha sp.
C. mollicula
C. sphaeralceae

Family Tingidae (Cont'd)

Dictyla coloradensis
Gargaphia opacula
Teleonemia nigrina

Order Homoptera - Scale Insects

Family Acanaloniidae

Acanalonia mollicula

Family Cicadellidae

Aceratagallia sp.
A. cinerea
Ballana sp.
Dixianus utahnus
Lycioides loculatus
Scaphytopius nigricollis
S. torridus
Spathanus acuminatus
Stragania sp.

Family Dictyopharidae

Scolops sp.

Family Flatidae

Melormenis infuscata
Mistharnophantia sonorana

Family Issidae

Hysteropterum sp.

Family Membracidae

Centrodontus atlas
Multareis cornutus
Multareoides bifurcatus

Order Hymenoptera - Ants and Wasps

Family Andrenidae

Andrena sp.
Calliopsis subalpinus
Perdita sp.
P. arcuata
P. callicerata
P. chloris
P. fallugiae
P. nasuta
P. thermophila

Family Anthophoridae

Anthophora sp.
A. californica
A. hololeuca
A. phenax
A. porterae
A. urbana
Centris rhodopus
Ceratina nanula
Diadasia australis
D. diminuta
Diadasia lutzi
Epeolus minimus

Family Anthophoridae (Cont'd)

Melissodes subagilis
M. tristis
Synhalonia 4 spp.
S. quadricincta
Triepeolus helianthi
Xeromelecta californica
Xylocopa californica

Family Apidae

Bombus morrisoni

Family Bradynobaenidae

Chyphotes melaniceps
C. petiolatus

Family Colletidae

Colletes sp.
C. eulophi
Hylaeus asininus

Family Formicidae

Acanthomyops interjectus
A. latipes
Aphaenogaster sp.
A. boulderensis
A. megommata

Family Formicidae (Cont'd)

Camponotus hyatti
C. ocreatus
C. semitestaceus
C. vicinus
Conomyrma bicolor
C. insana
Crematogaster coarctata
C. depilis
C. mutans
C. nocturna
Formica fusca
F. integroides
F. lasioides
F. limata
F. microgyna
F. moki
F. neogagates
F. neorufibarbis
F. obscuripes
F. obtusipilosa
F. subpolita
Iridomyrmex humilis
Lasius crypticus
L. sitiens
Leptothorax sp.
L. andrei
L. nevadensis
L. nitens
Leptothorax tricarinatus
Liometopum luctuosum
Messor sp.
M. lariversi
M. lobgnathus
M. pergandei
M. smithi
Monomorium minimum
Myrmecocystus sp.
M. comatus
M. flaviceps
M. koso
M. lugubris
M. mendax
Myrmecocystus mexicanus
M. mimicus
M. placodops
M. testaceus

Family Formicidae (Cont'd)

Myrmica emeryana
Neivamyrmex minor
Pheidole bicarinata
P. desertorum
P. inquilina
P. pilifera
Pogonomyrmex barbata
P. californicus
P. imberbiculus
P. magnacanthus
Pogonomyrmex occidentalis
P. rugosus
P. salinus
Solenopsis aurea
S. molesta
S. salina
S. xyloni
Stenama smithi

Family Halictidae

Agapostemon cockerelli
A. texanus
Dufourea 2 spp.
Halictus tripartitus
Lasioglossum 3 spp.
L. albohirtus
L. hyalinus
L. incompletus
L. microlepoides
Lasioglossum nevadensis
L. pruinosus
L. ruficornis
L. sisymbrii
Nomia tetrazonata
Sphecodes eustictus

Family Ichneumonidae

Ophion sp.

Family Megachilidae

Anthidium dammersi
Ashmeadiella aridula
A. australis
A. bigeloviae
A. inyoensis
Ashmeadiella opuntiae
Dianthidium pudicum
D. subparvum
D. ulkei

Family Megachilidae (Cont'd)

Dioxys productus
Heriades timberlakei
Lithurge apicalis
Megachile lobatifrons
Osmia sp.
O. titusi
Stelis sp.

Family Melittidae

Hesperapis willmattae

Family Mutillidae

Acanthophotopsis falciformis
Acrophotopsis eurygnathus
Dasymutilla gloriosa
D. klugii
D. paenulata
D. satanas
Dilophotopsis concolor
Odontophotopsis armata
O. clypeatus
O. cookii
O. infelix
O. mamatus
O. microdonta
O. obliquus
O. quadrispinosa
O. sercus
O. setifera
Sphaeropthalma brachyptera
S. acontius
S. amphion
S. angulifera

Family Mutillidae (Cont'd)

Sphaeropthalma becki
S. blakeii
S. difficilis
S. ferruginea
S. helicaon
S. macswaini
S. mendica
S. pallida
S. parapenalis
S. sonora
S. yumaella

Family Platygasteridae

Inostemma sp.
Platygaster sp.

Family Tiphiidae

Acanthetropis aequalis
A. noctivaga
Brachycistina acuta
Brachycistis glabrella
B. inaequalis
B. ioachinensis
B. linsleyi
B. triangularis
Colocistis brevis
C. castanea
C. crassa
Colocistis eremi
Quemaya paupercula

Family Vespidae

Vespula pensylvanica

Order Isoptera – Termites

Family Rhinotermitidae

Reticulitiermes basinensis
R. okanaganensis

Family Termitidae

Amitermes sp.

Order Lepiodoptera – Butterflies and Moths

Family Adelidae

Adela punctiferella

Family Arctiidae

Arachnis picta
Pygarctia murina

Family Coleophoridae

Coleophora sp.

Family Gelechiidae

Malacosoma fragilis

Family Geometridae

Caripeta sp.
Claucina sp. *
Lycia ypsilon
Nacophora sp.
Pero sp.
Semiothisa near *colorata*
S. larreana *

Family Heliodinidae

Heliodines near *sexpunctella*

Family Lasiocampidae

Gloveria arizonensis

Family Noctuidae

Conochares near *arizonae*
C. near *hutsoni* *
Grotella sp.
Oxycnemis near *gracillinea*
Phobolosia anfracta
Synedoida sp. *
Triocnemis sp.

Family Oecophoridae

Inga concolorella

Family Pieridae

Pontia protodice

Family Psychidae

Thyridopteryx meadii

Family Putellidae

Plutella maculipennis *

Family Pyralidae

Dichozoma parvipicta
Dioryctria near *gulosella*
Etiella zinckenella
Eumysia mysiella
Heterographis morrisonella
Hulstia undulatella
Loxostege albiceralis
Milgithea sp.
Nephopterix bifasciella
Ommatopteryx texana *

Family Pyralidae (Cont'd)

Passadena flavidorsella
Salebriacus odiosella
Sosipatra rileyella
Staudingeria albipenella

Family Saturniidae

Hemileuca nevadensis

Family Satyridae

Cercyonis sp.

Family Scythrididae

Scythris 12 spp.

Family Sphingidae

Celerio lineata *
Hyles lineata
Sphinx dollii

Family Tineidae

Acrolophus 4 spp.
A. laticapitana
A. variabilis
Dyotopasta yumaella
Myrmecozela near *obliquella* *
Tinea sp.

Family Tortricidae

Decodes fragariana
Eucosma bobana
E. near *bolanderana*
Ofatulena duodecemstriata
Pelochrista rorana
Phaneta indagatricana
p. setonana
Platynota labiosana
P. near *yumana*

Family Ypsolophidae

Ypsolopha sp.
Y. near *angelicella*
Y. near *delicatella*
Y. near *flavistrigella*

Order Mantodea - Mantids

Family Mantidae

Litaneutria minor
Stagmomantis californica

Order Odonata – Dragonflies and Damselflies

Suborder Anisoptera - Dragonflies

Family Libellulidae

Unknown sp.

Suborder Zygoptera - Damselflies

Family Coenagrionidae

Argia sp.

Order Orthoptera – Grasshoppers and Crickets

Family Acrididae

Aeoloplides minor
A. tenuipennis
Ageneotettix sp.
A. deorum
Amphitornus coloradus
Anconia integra
Arphia conspersa
Cibolacris parviceps
Cordillacris occipitalis
Derotmema delicatulum
Hesperotettix nevadensis
H. viridis
Leprus wheeleri
Ligurotettix coquilletti
Melanoplus aridus
M. complanatipes
Mestobregma impexum
Paraidemona punctatus
Paropomala pallida
Poecilotettix sanguineus
Psoloessa delicatula
Trimerotropis albescens
T. californica
T. cyaneipennis
T. fontana
T. inconspicua
T. pallidipennis
T. sparsa
Tytthotyle maculatus
Xanthippus corallipes

Family Eumastacidae

Morsea californica

Family Gryllacrididae

Ceuthophilus lamellipes
Hemiudeopsylla fossor
H. hesperus
Pristoceuthophilus pacificus
Stenopelmatus fuscus

Family Gryllidae

Cycloptilum comprehendens
Gryllus assimilis
Myrmecophilus manni
Oecanthus californicus
O. nigricornis

Family Rhaphidophoridae

Ceuthophilus deserticola
C. nevadensis
Gammarotettix bilobatus

Family Romaleidae

Dracotettix plutonius

Family Tanaoceridae

Tanaocerus koebelei

Family Tettigoniidae

Arethaea brevicauda
Atelopus luteus
Capnobates arizonensis
C. fuliginosa
C. occidentalis
Insara covilleae
I. elegans

Order Phasmatodea - Walkingsticks

Family Phasmatidae

Parabacillus hesperus
Pseudosermyle stramineus

Order Siphonaptera - Fleas

Family Ceratophyllidae

Aetheca wagneri
Dactylopsylla bluei
Diamanus montanus *
Eumolpianus eumolpi
Foxella ignotus
Malaraeus euphorbi *
M. sinomus
M. telchimun
Orchopeas sexdentatus
Thrassis aridis
T. bacchi
Traubella neotomae

Family Ctenophthalmidae

Anomiopsyllus amphibolus
A. amphibolus
Callistopsyllus deuterus
C. deuterus
Carteretta carteri
Catallagia decipiens
Epitedia wenmanni
Megarthroglossus procus
Meringis dipodomys
M. hubbardi
M. parkeri

Family Ctenophthalmidae (Cont'd)

Rhadinopsylla heiseri
R. sectilis
Stenistomera alpina
S. alpina

Family Hystrichopsyllidae

Atyphloceras echis

Family Ichnospyllidae

Nycteridopsylla vancouverensis

Family Leptopsyllidae

Jordanopsylla allredi
Odontopsyllus dentatus
Peromyscopsylla hesperomys

Family Pulicidae

Echidnophaga gallinaceus
Hoplopsyllus anomalus
Pulex irritans
Spilopsyllus inaequalis

Order Thysanoptera - Thrips

Family Phlaeothripidae

Leptothrips mali

Family Thripidae

Frankliniella minutus

Order Trichoptera - Caddice Flies

Family Limnephilidae

Limnephilus sp.

Subphylum Myripoda

Class Chilopoda -Centipedes

Family Gosibiidae
Gosibius arizonensis *
Family Lithobiidae
Oabius mercurialis *
Family Schendylidae
Nyctunguis stenus *

Family Scolopendridae
Scolopendra heros *
S. michelbacheri
Family Tampiyidae
Abatorus allredi *
Eremorus becki *

Class Diplopoda - Millipedes

Family Atopetholidae
Arinolus nevadae *
A. sequens *
Orthichelus michelbacheri *

Family Leioderidae
Titsona tida *

PHYLUM MOLLUSCA (MOLLUSKS)

Class Bivalvia - Clams

Family Pisidiidae
Pisidium sp.

Class Gastropoda - Snails and Slugs

Family Hydrobiidae
Pyrgulopsis turbatrix

PHYLUM NEMATA (NEMATODES)

Order Dorylaimida - Omnivores

Family Leptonchidae
Leptonchus sp.
Family Dorylaimidae
Pungentus sp.

Family Qudsianematidae
Ecumenicus sp.
Ecumenicus monohystera

Order Rhabditida - Insect-parasitic

Family Cephalobidae
Acrobeles complexus

Family Elaphonamatidae
Elaphonema sp.

Order Tylenchida - Plant-parasitic

Family Anguinidae
Ditylenchus sp.
Family Aphelenchidae
Aphelenchus avenae

Family Aphelenchoididae
Aphelenchoides sp.
Family Belonolaimidae
Merlinius grandis

Family Tylenchina

Tylenchorhynchus 3 spp.
Tylenchorhynchus cylindricus

* Designates species in which the listing was unable to be verified or updated.

VERTEBRATES

PHYLUM CHORDATA (CHORDATES)

Class Actinopterygii: Ray-finned Fish

Order Cypriniformes - Carps

Family Cyprinidae

Carassius auratus	Goldfish
Notemigonus crysoleucas	Golden Shiner

Order Perciformes - Perch-like

Family Centrarchidae

Lepomis machrochirus	Bluegill

Class Aves: Birds

Order Anseriformes - Waterfowl

Family Anatidae

Aix sponsa	Wood Duck
Anas acuta	Northern Pintail
A. americana	American Wigeon
A. clypeata	Northern Shoveler
A. crecca	Green-winged Teal
A. cyanoptera	Cinnamon Teal
A. discors	Blue-winged Teal
A. platyrhynchos	Mallard
A. strepera	Gadwall
Aythya affinis	Lesser Scaup
A. americana	Redhead
A. collaris	Ring-necked Duck
A. valisineria	Canvasback
Branta canadensis	Canada Goose
Bucephala albeola	Bufflehead
B. clangula	Common Goldeneye
Chen caerulescens	Snow Goose
Cygnus columbianus	Tundra Swan
Melanitta perspicillata	Surf Scoter
Mergus merganser	Common Merganser
M. serrator	Red-breasted Merganser
Oxyura jamaicensis	Ruddy Duck

Order Apodiformes - Swifts and Hummingbirds

Family Apodidae

Aeronautes saxatalis	White-throated Swift

Family Trochilidae

Archilochus alexandri	Black-chinned Hummingbird
Calypte costae	Costa's Hummingbird
Selasphorus platycercus	Broad-tailed Hummingbird
S. rufus	Rufous Hummingbird

Order Caprimulgiformes - Goatsuckers and Allies

Family Caprimulgidae

Chordeiles acutipennis	Lesser Nighthawk
C. minor	Common Nighthawk
Phalaenoptilus nuttallii	Common Poorwill

Order Charadriiformes - Shorebirds, Gulls, and Alcids

Family Charadriidae

Charadrius alexandrinus	Snowy Plover
C. montanus **	Mountain Plover
C. semipalmatus	Semipalmated Plover
C. vociferus	Killdeer
Pluvialis dominica	American Golden Plover
P. squatarola	Black-bellied Plover

Family Laridae

Chlidonias niger **	Black Tern
Larus argentatus	Herring Gull
L. californicus	California Gull
L. delawarensis	Ring-billed Gull
L. philadelphia	Bonaparte's Gull
L. pipixcan	Franklin's Gull
Sterna caspia	Caspian Tern
S. forsteri	Forster's Tern

Family Recurvirostridae

Himantopus mexicanus	Black-necked Stilt
Recurvirostra americana	American Avocet

Family Scolopacidae

Actitis macularia	Spotted Sandpiper
Calidris alpina	Dunlin
C. bairdii	Baird's Sandpiper
C. himantopus	Stilt Sandpiper
C. mauri	Western Sandpiper
C. melanotos	Pectoral Sandpiper
C. minutilla	Least Sandpiper
Catoptrophorus semipalmatus	Willet

Family Scolopacidae (Cont'd)

Gallinago gallinago	Common Snipe
Limnodromus scolopaceus	Long-billed Dowitcher
Limosa fedoa	Marbled Godwit
Numenius americanus	Long-billed Curlew
Phalaropus lobatus	Red-necked Phalarope
P. tricolor	Wilson's Phalarope
Tringa flavipes	Lesser Yellowlegs
T. melanoleuca	Greater Yellowlegs
T. solitaria	Solitary Sandpiper

Order Ciconiiformes - Herons, Ibises, and Storks

Family Ardeidae

Ardea alba egretta	Great Egret
A. herodias	Great Blue Heron
Botaurus lentiginosus	American Bittern
Bubulcus ibis	Cattle Egret
Butorides striatus *	Green-backed Heron
B. virescens	Green Heron
Egretta thula	Snowy Egret
Ixobrychus exilis **	Least Bittern
Nycticorax nycticorax	Black-crowned Night-Heron

Family Cathartidae

Cathartes aura	Turkey Vulture

Family Threskiornithidae

Ajaia ajaja	Roseate Spoonbill
Plegadis chihi **	White-faced Ibis

Order Columbiformes - Pigeons and Allies

Family Columbidae

Columba livia	Rock Dove
Zenaida macroura	Mourning Dove

Order Coraciiformes - Rollers, Kingfishers, and Allies

Family Alcedinidae

Ceryle alcyon	Belted Kingfisher

Order Cuculiformes - Cuckoos and Allies

Family Cuculidae

Coccyzus americanus	Yellow-billed Cuckoo
Geococcyx californianus	Greater Roadrunner

Order Falconiformes - Diurnal Birds of Prey

Family Accipitridae

Accipiter cooperii	Cooper's Hawk
A. gentilis	Northern Goshawk
A. striatus	Sharp-shinned Hawk
Aquila chrysaetos	Golden Eagle
Buteo jamaicensis	Red-tailed Hawk
B. lagopus	Rough-legged Hawk
B. regalis **	Ferruginous Hawk
B. swainsoni	Swainson's Hawk
Circus cyaneus	Northern Harrier
Haliaeetus leucocephalus **	Bald Eagle
Pandion haliaetus	Osprey

Family Falconidae

Falco mexicanus	Prairie Falcon
F. peregrinus **	American Peregrine Falcon
F. sparverius	American Kestrel

Order Galliformes - Gallinaceous Birds

Family Odontophoridae

Callipepla gambelii	Gambel's Quail

Family Phasianidae

Alectoris chukar	Chukar
Phasianus colchicus	Ring-necked Pheasant

Order Gaviiformes - Loons

Family Gaviidae

Gavia immer	Common Loon

Order Gruiformes - Rails, Cranes, and Allies

Family Rallidae

Fulica americana	American Coot
Gallinula chloropus	Common Moorhen
Porzana carolina	Sora

Order Passeriformes - Perching Birds

Family Aegithalidae

Psaltriparus minimus	Bushtit

Family Alaudidae

Eremophila alpestris	Horned Lark

Family Bombycillidae

Bombycilla cedrorum	Cedar Waxwing

Family Cardinalidae

Guiraca caerulea	Blue Grosbeak
Passerina amoena	Lazuli Bunting
P. cyanea	Indigo Bunting
Pheucticus ludovicianus	Rose-breasted Grosbeak
P. melanocephalus	Black-headed Grosbeak

Family Corvidae

Aphelocoma californica	Western Scrub-Jay
Corvus brachyrhynchos	American Crow
C. corax sinuatus	Common Raven
Cyanocitta stelleri	Steller's Jay
Gymnorhinus cyanocephalus	Pinyon Jay
Nucifraga columbiana	Clark's Nutcracker
Pica hudsonia	Black-billed Magpie

Family Emberizidae

Amphispiza belli	Sage Sparrow
A. bilineata	Black-throated Sparrow
Calcarius lapponicus	Lapland Longspur
Chondestes grammacus	Lark Sparrow
Junco hyemalis	Dark-eyed Junco
Melospiza lincolnii	Lincoln's Sparrow
M. melodia	Song Sparrow
Passerculus sandwichensis	Savannah Sparrow
Passerella iliaca	Fox Sparrow
Pipilo chlorurus	Green-tailed Towhee
P. maculatus	Spotted Towhee
Pooecetes gramineus	Vesper Sparrow
Spizella atrogularis	Black-chinned Sparrow
S. breweri	Brewer's Sparrow
S. passerina	Chipping Sparrow
Zonotrichia atricapilla	Golden-crowned Sparrow
Z. leucophrys	White-crowned Sparrow

Family Fringillidae

Carduelis pinus pinus	Pine Siskin
C. psaltria	Lesser Goldfinch
C. tristis	American Goldfinch
Carpodacus cassinii	Cassin's Finch
C. mexicanus	House Finch
C. purpureus	Purple Finch
Coccothraustes vespertinus	Evening Grosbeak
Loxia curvirostra	Red Crossbill

Family Hirundinidae

Hirundo rustica	Barn Swallow
Petrochelidon pyrrhonota	Cliff Swallow
Riparia riparia	Bank Swallow
Stelgidopteryx serripennis	Northern Rough-winged Swallow
Tachycineta bicolor	Tree Swallow
T. thalassina	Violet-green Swallow

Family Icteridae

Agelaius phoeniceus	Red-winged Blackbird
Euphagus cyanocephalus	Brewer's Blackbird
Icterus bullockii	Bullock's Oriole
I. cucullatus	Hooded Oriole
I. galbula	Baltimore Oriole
I. parisorum	Scott's Oriole
Molothrus ater	Brown-headed Cowbird
Quiscalus mexicanus	Great-tailed Grackle
Q. quiscula *	Common Grackle
Sturnella neglecta	Western Meadowlark
Xanthocephalus xanthocephalus	Yellow-headed Blackbird

Family Laniidae

Lanius ludovicianus	Loggerhead Shrike

Family Mimidae

Dumetella carolinensis	Gray Catbird
Mimus polyglottos	Northern Mockingbird
Oreoscoptes montanus	Sage Thrasher
Toxostoma crissale	Crissal Thrasher
T. lecontei	Le Conte's Thrasher
T. rufum	Brown Thrasher

Family Motacillidae

Anthus rubescens	American Pipit
A. spragueii	Sprague's Pipit

Family Paridae

Baeolophus inornatus	Oak Titmouse
Poecile gambeli	Mountain Chickadee

Family Parulidae

Dendroica coronata	Yellow-rumped Warbler
D. nigrescens	Black-throated Gray Warbler
D. pensylvanica	Chestnut-sided Warbler
D. petechia	Yellow Warbler
D. townsendi	Townsend's Warbler
Geothlypis trichas	Common Yellowthroat
Icteria virens	Yellow-breasted Chat
Oporornis tolmiei	MacGillivray's Warbler
Seiurus noveboracensis	Northern Waterthrush

Family Parulidae (Cont'd)

Setophaga ruticilla	American Redstart
Vermivora celata	Orange-crowned Warbler
V. ruficapilla	Nashville Warbler
V. virginiae	Virginia's Warbler
Wilsonia pusilla	Wilson's Warbler

Family Passeridae

Passer domesticus	House Sparrow

Family Ptilogonatidae

Phainopepla nitens **	Phainopepla

Family Regulidae

Regulus calendula	Ruby-crowned Kinglet

Family Sittidae

Sitta canadensis	Red-breasted Nuthatch
S. carolinensis	White-breasted Nuthatch

Family Sturnidae

Sturnus vulgaris	European Starling

Family Sylviidae

Polioptila caerulea	Blue-gray Gnatcatcher
P. melanura	Black-tailed Gnatcatcher

Family Thraupidae

Piranga ludoviciana	Western Tanager

Family Troglodytidae

Campylorhynchus brunneicapillus	Cactus Wren
Catherpes mexicanus	Canyon Wren
Cistothorus palustris	Marsh Wren
Salpinctes obsoletus	Rock Wren
Thryomanes bewickii	Bewick's Wren
Troglodytes aedon	House Wren

Family Turdidae

Catharus guttatus	Hermit Thrush
C. ustulatus	Swainson's Thrush
Ixoreus naevius	Varied Thrush
Myadestes townsendi	Townsend's Solitaire
Sialia currucoides	Mountain Bluebird
S. mexicana	Western Bluebird
Turdus migratorius	American Robin

Family Tyrannidae

Contopus cooperi	Olive-sided Flycatcher
C. sordidulus	Western Wood Pewee
Empidonax difficilis	Pacific-slope Flycatcher
E. hammondii	Hammond's Flycatcher

Family Tyrannidae (Cont'd)

E. oberholseri	Dusky Flycatcher
E. wrightii **	Gray Flycatcher
Myiarchus cinerascens	Ash-throated Flycatcher
Pyrocephalus rubinus	Vermilion Flycatcher
Sayornis nigricans	Black Phoebe
S. saya	Say's Phoebe
Tyrannus forficatus	Scissor-tailed Flycatcher
T. verticalis	Western Kingbird
T. vociferans	Cassin's Kingbird

Family Vireonidae

Vireo gilvus	Warbling Vireo
V. solitarius	Blue-headed Vireo
V. vicinior	Gray Vireo

Order Pelecaniformes - Totipalmate Swimmers

Family Pelecanidae

Pelecanus erythrorhynchos	American White Pelican
P. occidentalis	Brown Pelican

Family Phalacrocoracidae

Phalacrocorax auritus	Double-crested Cormorant

Order Piciformes - Woodpeckers and Allies

Family Picidae

Colaptes auratus	Northern Flicker
Melanerpes lewis	Lewis's Woodpecker
Picoides scalaris	Ladder-backed Woodpecker
P. villosus	Hairy Woodpecker
Sphyrapicus nuchalis	Red-naped Sapsucker
S. thyroideus	Williamson's Sapsucker
S. varius	Yellow-bellied Sapsucker

Order Podicipediformes - Grebes

Family Podicipedidae

Aechmophorus occidentalis	Western Grebe
Podiceps nigricollis	Eared Grebe
Podilymbus podiceps	Pied-billed Grebe

Order Strigiformes - Owls

Family Strigidae

Asio flammeus	Short-eared Owl
A. otus	Long-eared Owl
Athene cunicularia **	Burrowing Owl
Bubo virginianus	Great Horned Owl

Family Tytonidae

Tyto alba	Barn-Owl

Class Lissamphibia: Amphibians

Order Anura – Frogs and Toads

Family Ranidae

Rana catesbeiana	Bullfrog

Order Caudata - Salamanders and Newts

Family Ambystomatidae

Ambystoma tigrinum	Tiger Salamander

Class Mammalia: Mammals

Order Artiodactyla - Hoofed Mammals

Family Antilocapridae

Antilocapra americana	Pronghorn Antelope

Family Bovidae

Bos taurus	Cow
Ovis canadensis	Bighorn Sheep

Family Cervidae

Odocoileus hemionus	Mule Deer

Order Carnivora - Carnivores

Family Canidae

Canis latrans	Coyote
Urocyon cinereoargenteus	Grey Fox
Vulpes macrotis	Kit Fox

Family Felidae

Felis concolor	Mountain Lion
Lynx rufus	Bobcat

Family Mustelidae

Mustela frenata	Long-tailed Weasel
Spilogale putorius	Western Spotted Skunk
Taxidea taxus	Badger

Family Procyonidae

Bassariscus astutus	Ring-tailed Cat

Order Chiroptera - Bats

Family Molossidae

Tadarida brasiliensis	Brazilian Free-tailed Bat

Family Vespertilionidae

Antrozous pallidus	Pallid Bat
Corynorhinus townsendii **	Townsend's Big-eared Bat
Eptesicus fuscus	Big Brown Bat
Euderma maculatum **	Spotted Bat
Lasionycteris noctivagans	Silver-haired Bat
Lasiurus blossevillii	Western Red Bat
L. cinereus	Hoary Bat
Myotis californicus	California Bat
M. ciliolabrum **	Small-footed Myotis
M. evotis **	Long-eared Myotis
M. thysanodes **	Fringed Myotis
M. volans **	Long-legged Myotis
M. yumanensis	Yuma Myotis
Pipistrellus hesperus	Western Pipistrelle Bat

Order Insectivora – Shrews and Moles

Family Soricidae

Notiosorex crawfordi	Desert Shrew
Sorex merriami	Merriam's Shrew
S. tenellus	Inyo Shrew

Order Lagomorpha – Pikas, Rabbits and Hares

Family Leporidae

Lepus californicus	Black-tailed Jackrabbit
Sylvilagus audubonii	Desert Cottontail
S. nuttallii	Mountain Cottontail

Order Perissodactyla - Horses

Family Equidae

Equus asinus	Burro
E. caballus	Horse

Order Rodentia - Rodents

Family Cricetidae

Lagurus curtatus	Sagebrush Vole

Family Erethizontidae

Erethizon dorsatum	Porcupine

Family Geomyidae

Thomomys bottae	Botta's Pocket Gopher
T. umbrinus	Pygmy Pocket Gopher

Family Heteromyidae

Chaetodipus formosus	Longtail Pocket Mouse
Dipodomys deserti	Desert Kangaroo Rat
D. merriami	Merriam's Kangaroo Rat
D. microps	Great Basin Kangaroo Rat
D. ordii	Ord Kangaroo Rat
Microdipodops megacephalus	Dark Kangaroo Mouse
Perognathus longimembris	Little Pocket Mouse
P. parvus	Great Basin Pocket Mouse

Family Muridae

Neotoma lepida	Desert Woodrat
Onychomys torridus	Southern Grasshopper Mouse
Peromyscus crinitus	Canyon Mouse
P. eremicus	Cactus Mouse
P. maniculatus	Deer Mouse
P. truei	Pinon Mouse
Reithrodontomys megalotis	Western Harvest Mouse

Family Sciuridae

Ammospermophilus leucurus	White-tailed Antelope-squirrel
Eutamias dorsalis	Cliff Chipmunk
Spermophilus tereticaudus	Round-tailed Ground Squirrel
S. townsendii	Towsend's Ground Squirrel
S. variegatus	Rock Squirrel

Class Reptilia: Lizards, Snakes and Tortoises

Order Squamata - Lizards and Snakes

Suborder Lacertilia - Lizards

Family Crotaphytidae

Crotaphytus insularis	Great Basin Collared Lizard
Gambelia wislizenii	Long-nosed Leopard Lizard

Family Gekkonidae

Coleonyx variegatus	Desert Banded Gecko

Family Helodermatidae

Heloderma suspectum * **	Banded Gila Monster

Family Iguanidae

Dipsosaurus dorsalis	Desert Iguana
Sauromalus obesus **	Chuckwalla

Family Phrynosomatidae

Callisaurus draconoides	Common Zebra-tailed Lizard
Phrynosoma platyrhinos	Desert Horned lizard
Sceloporus graciosus	Sagebrush Lizard
S. magister	Yellow-backed Spiny Lizard
S. occidentalis	Western Fence Lizard
Uta stansburiana	Side-blotched Lizard

Family Scincidae

Eumeces gilberti	Gilbert's Skink
E. skiltonianus	Western Skink

Family Teiidae

Cnemidophorus tigris	Western Whiptail Lizard

Family Xantusidae

Xantusia vigilis	Desert Night Lizard

Suborder Serpentes - Snakes

Family Colubridae

Arizona elegans	Desert Glossy Snake
Chionactis occipitalis	Nevada Shovel-nosed Snake
Diadophis punctatus	Ring-necked Snake
Hypsiglena torquata	Night Snake
Lampropeltis getula	California Kingsnake
Masticophis flagellum	Red Racer
M. taeniatus	Desert Striped Whipsnake
Phyllorhynchus decurtatus	Western Leaf-Nosed Snake
Pituophis catenifer	Great Basin Gopher Snake
Rhinocheilus lecontei	Western Long-nosed Snake
Salvadora hexalepis	Mohave Patch-nosed Snake
Sonora semiannulata	Great Basin Ground Snake
Tantilla hobartsmithi	Southwestern Black-headed Snake
Trimorphodon biscutatus	Western Lyre Snake

Family Leptotyphlopidae

Leptotyphlops humilis	Western Slender Blind Snake

Family Viperidae

Crotalus cerastes	Mojave Desert Sidewinder
C. mitchellii	Panamint Rattlesnake

Order Testudines - Turtles and Tortoises

Family Testudinidae

Gopherus agassizii **	Desert Tortoise

* Designates species in which the listing was unable to be verified or updated.

** Designates a species considered important because of federal protective status or concern.

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ANNUAL SITE ENVIRONMENTAL REPORTS

The following is a list of Annual Site Environmental Reports which were purposely not included in the annotated bibliography. These reports are produced annually for the U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office and by the U.S. Department of Energy, Office of Civilian Radioactive Waste Management. They summarize results of radiological and non-radiological monitoring and surveillance of the NTS environment and report all compliance activities related to environmental regulations germane to the NTS. Readers interested in radiological surveillance data for air, surface water, groundwater, and soil are encouraged to access these reports. Although ecological monitoring of flora and fauna of the NTS may, in some years, be summarized in these documents, such activities and data are reported in more detail in other documents which have been included in the annotated bibliography.

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REECo (Reynolds Electrical & Engineering Co., Inc). 1966. Environmental Radioactivity at the Nevada Test Site July 1965 through June 1966. NVO-162-25, Radiological Sciences Department, Site Facilities Division, Mercury, NV.

REECo. 1968. Environmental Radioactivity at the Nevada Test Site July, 1966 through June, 1967. NVO-410-15, Environmental Sciences Department, Las Vegas, NV.

REECo. 1969. Environmental Radioactivity at the Nevada Test Site July, 1967 through June, 1968. NVO-410-22, Environmental Sciences Department, Las Vegas, NV.

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