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ECOLOGY OF THE WESTERN BURROWING OWL ON THE NEVADA TEST SITE

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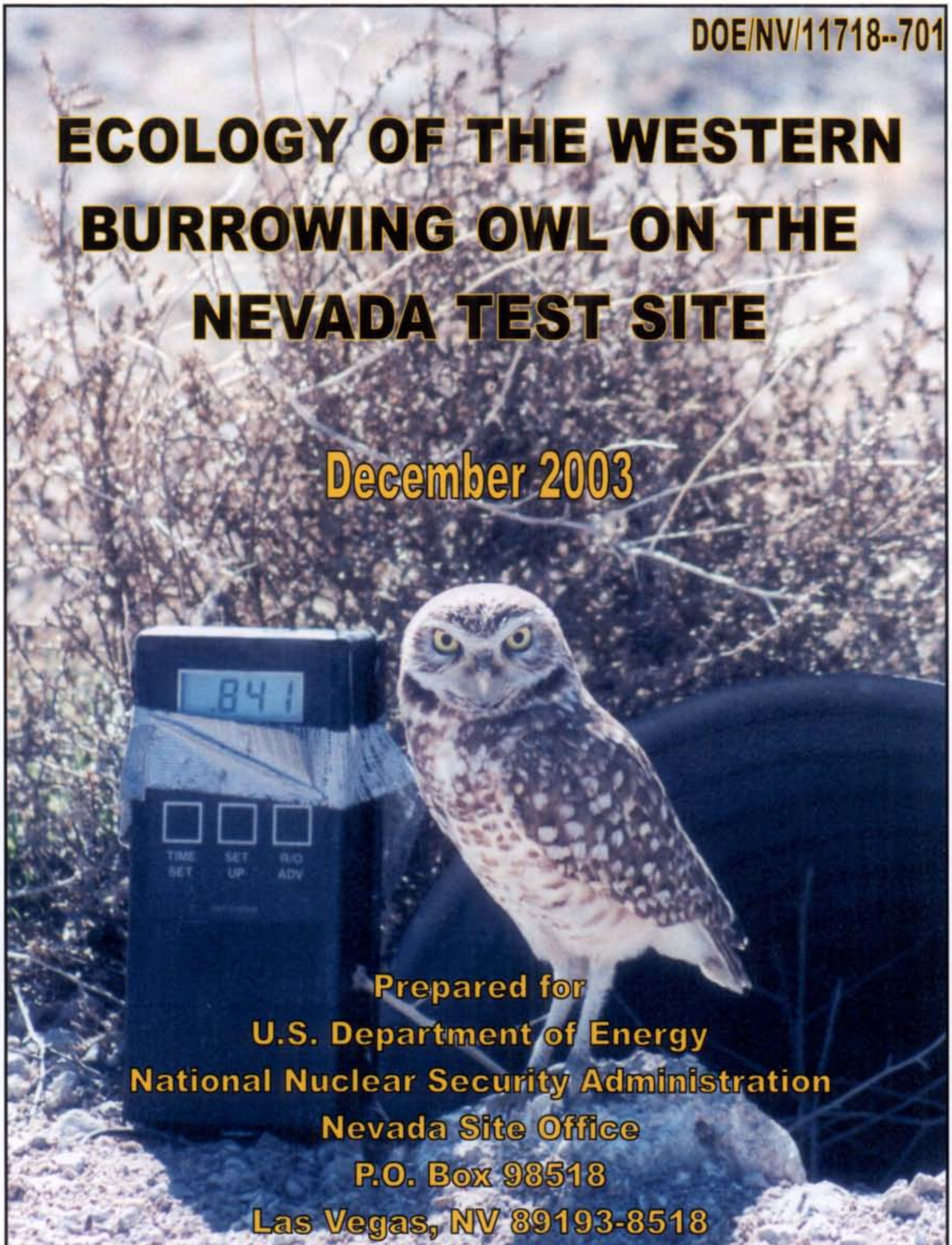

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Bechtel Nevada
Ecological Services

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ECOLOGY OF THE WESTERN BURROWING OWL ON THE NEVADA TEST SITE

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December 2003

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ACRONYMS AND ABBREVIATIONS

BURS	Burrow use rate by burrow site
BURM	Burrow use rate by month and ecoregion
BRR	Burrow reuse rate
°C	degrees Celsius
cm	centimeter
DOE	U.S. Department of Energy
DOE/NV	U.S. Department of Energy, Nevada Operations Office
EMAC	Ecological and Monitoring Compliance Program
ESRI	Environmental Systems Research Institute
GIS	Geographic Information System
km	kilometer
m	meter
MBTA	Migratory Bird Treaty Act
n	sample size
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NTS	Nevada Test Site
s.d.	standard deviation
TM1500	TrailMaster® camera system, Model TM1500
USFWS	U.S. Fish and Wildlife Service
UTM	Universal Transverse Mercator

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EXECUTIVE SUMMARY

The western burrowing owl (*Athene cunicularia hypugaea*), hereafter referred to as owl, is one of many animal species of concern that occur on the Nevada Test Site (NTS). It is a relatively small, long-legged, ground-dwelling owl found in flat, open grasslands, steppes, deserts, prairies, and agricultural lands throughout the Central and Western United States, south-central Canada, Mexico, and Central America. Because of declines in the abundance of this species, owls were listed by the U.S. Fish and Wildlife Service as a candidate for classification as threatened or endangered under the Endangered Species Act. Although removed from that list in 1996 when the listing process for candidate species was revised, the owls are still regarded as a National Bird of Conservation Concern by the U.S. Fish and Wildlife Service, and they are protected under the Migratory Bird Treaty Act. In Nevada, owls are classified as Protected by the state and as a proposed Sensitive species by the U.S. Bureau of Land Management. Although data is sparse and perhaps insufficient, population trends for the owl in Nevada appear to be stable. However, localized population decreases have been noted, especially in southern Nevada (Clark County), and in the Lahontan Valley. The statewide population was roughly estimated at 1,000 to 10,000 pairs in 1992.

Compared to most other special status animal species on the NTS, the owl requires greater management attention because it occupies the flat, open valley bottoms where most ongoing activities are occurring and where most future activities are likely to occur. In addition, because owls occur near NTS activities, listing of this species as threatened or endangered may result in restrictions being placed on NTS activities in order to protect owls. Therefore, owls were monitored to: (1) obtain data on the ecology and natural history of this species on the NTS, (2) determine what impacts, if any, the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) activities have on this species, and (3) develop mitigation recommendations in the event the owl is ever listed under the Endangered Species Act. This report summarizes the results of these monitoring efforts.

Owls occur in each of the three ecoregions (i.e., Great Basin Desert, Mojave Desert, and transition) found on the NTS, primarily in the large, open areas of Yucca Flat, Frenchman Flat, Jackass Flats, and near Buckboard Mesa. A total of 119 owl locations including 89 burrow sites and 30 sighting locations have been documented on the NTS. Of these 119 locations, 64 occur in the transition ecoregion, 38 occur in the Mojave Desert ecoregion, 11 occur in the Great Basin Desert ecoregion, and 6 are at unspecified locations. Generally, most of the locations on the NTS occur in areas with relatively deep washes with defined banks, mounds of dirt or excavations, disturbances containing partially buried metal culverts and pipes, or roadcuts.

Burrows were monitored for owl activity (e.g., fresh sign, owls) at least monthly from November 1997 through May 1998 and from November 1998 through December 2001. A total of 120 burrows in human-altered habitat and 44 burrows in natural habitat were monitored for owl use at 71 burrow sites. Of the 120 burrows in human-altered habitat, 75 were culverts, 22 were pipes, and 23 were earthen. Of the 44 burrows in natural habitat, 24 were wash burrows and 20 were non-wash burrows. NNSA/NSO activities such as emplacing culverts and pipes, road building, digging pits and channels, and mound building have benefited the owl directly by increasing the number of available burrows for owls to use, and indirectly by altering the natural habitat so it is more suitable for owls (e.g., increased opportunities for predators to dig burrows in altered soil because owls use abandoned predator burrows, more open habitat).

Active owl use (owls present or fresh sign) was detected at over 80 percent of the sites monitored. Overall, owl use at each burrow site averaged about 30 percent with no significant differences in use among ecoregions. In contrast, significant differences in use were detected among burrow types. Burrow sites containing both culvert and pipe burrows had significantly higher use rates (51.5 percent) than burrow sites having only culvert burrows (27.8 percent), earthen burrows in human-altered habitat (24.9 percent) or earthen burrows in natural habitat (23.1 percent).

Burrow use rate was also determined by month and ecoregion. Overall, the Mojave Desert ecoregion had the lowest use rate (19.8 percent). The Great Basin Desert ecoregion and the transition ecoregion had similar and higher use rates (32.3 and 30.2 percent, respectively). Use rates indicate increased use from March to May which suggests that owls were immigrating to or migrating through the NTS during this time period. Use rates then generally decreased at various rates to their lowest point during December to February. An exception to this general use pattern occurred in the Mojave Desert ecoregion. During September, use rates increased sharply and dropped again in October. This spike in use may have been due to dispersing juveniles searching for their own burrows or from migrating owls that used burrows in this ecoregion as stopover points as they headed south. The peak of use in the spring may have been from resident or migrating owls that were searching for suitable breeding burrows or from migrating owls just passing through on their way northward.

Reproduction and activity patterns were monitored at active burrows (i.e., burrows with fresh sign or owls) using TrailMaster® camera systems during the breeding seasons of 1999, 2000, and 2001. This system records each break in an infrared light beam between a transmitter and receiver placed on the apron of an owl burrow. Each break is considered an event, and photographs are taken for a subset of all events recorded at a burrow. Overall, breeding was detected at almost half of all sites sampled (13 in transition ecoregion, 3 in Mojave Desert ecoregion, 3 in Great Basin Desert ecoregion). Most nest burrows were in metal culverts or metal or plastic pipes. Reproduction was highest and most consistent in the transition ecoregion. The transition ecoregion, primarily Yucca Flat, provides the most suitable and productive breeding habitat for owls on the NTS. This is largely due to the abundance of artificial burrows and vegetation changes created by past testing activities in this area. These artificial burrows make suitable burrows for owls and other animals.

A total of 26 breeding pairs and 122 young were detected over the three-year period. Seven, 8, and 11 breeding pairs and 24, 43, and 55 young were detected during 1999, 2000, and 2001; respectively. The increase in the number of breeding pairs over time is due to finding new burrows to sample during each year. The average number of young per breeding pair during the entire period was 4.7 which is at the upper end of the range reported by other researchers. The average number of young per breeding pair by year was 3.4, 5.6, and 5.0 during 1999, 2000, and 2001; respectively. There appears to be a positive correlation between October to March precipitation and the number of young per pair. The average number of young per breeding pair by ecoregion was 5.0, 4.5, and 3.0 in the transition, Great Basin Desert, and Mojave Desert ecoregions; respectively. The TrailMaster® camera system is a cost-effective technique for documenting the number of owl breeding pairs and young.

Results from the photographs reveal that the maximum number of young owls per nest burrow were most frequently detected between 0500-1000 and 1800-2200 with peaks at 0700-0800 and 1900-2000. The highest frequency of prey delivery and feeding occurred between 2000-0100 and 0300-0500. No prey delivery or feeding was detected between 0600-0800, 1100-1200, nor 1300-1900. Young and adult owls were detected at the burrow entrance at all times throughout the day and night. However, they exhibited different activity patterns with adult owls being detected more frequently at the burrow apron during afternoon/early evening than young owls. Results from the full set of event data (n=45,188) show almost identical patterns of owl activity as do the photographs (n=2,225). Owls were active during all hours of the day and night with peaks of activity right around dawn, during the mid-morning hours, and in late afternoon and evening; thus exhibiting a trimodal activity distribution.

Owl food habits were studied by collecting and analyzing regurgitated pellets. Pellets were collected from November 1997 to April 1998 and November 1998 to July 2000. A total of 292 samples from 48 burrow sites, representing approximately 1,631 pellets, were analyzed for prey contents. A sample consisted of all the pellets collected from a given burrow site on a given date. Binomial logistic regression was used to determine significant differences ($P \leq 0.05$) among ecoregion and season. A total of 20 taxa were identified in the analysis, including 7 taxa of invertebrates and 13 taxa of vertebrates.

Across the NTS as a whole; crickets and grasshoppers, beetles, sun spiders, all rodents combined, and scorpions were the most common prey items eaten, occurring in more than half of the samples. Kangaroo rats (*Dipodomys* spp.) were the most common rodent remains found in the pellets. The percent frequency of pellets containing fragments of any invertebrate was substantially higher (95.5 percent) than the frequency of pellets containing fragments of any vertebrate (66.6 percent).

Invertebrates were a common food source in all three ecoregions. Based on results from the regression analysis, the frequency of occurrence of scorpions, true bugs, reptiles, white-footed mice (*Peromyscus* spp.), other rodents, and western harvest mice (*Reithrodontomys megalotis*) was highest in pellets collected from burrow sites in the Great Basin Desert ecoregion. The frequency of occurrence of Perognathinae and kangaroo rat remains was highest in pellets collected from the Mojave Desert and transition ecoregions, respectively. The frequency of occurrence of sun spiders was significantly higher in pellets from the Great Basin Desert ecoregion than in pellets from the transition ecoregion. No significant differences among ecoregions were found for frequency of occurrence of pellets containing fragments of any invertebrate and of any vertebrate. The most diverse diet (based on number of taxa) was detected in the transition ecoregion with all taxa represented, and the least diverse diet was detected in the Mojave Desert ecoregion.

The most common invertebrate orders found in owl pellets (i.e., crickets and grasshoppers, beetles, sun spiders, and scorpions) varied significantly in their frequency of occurrence in owl pellets across seasons. The frequency of occurrence of any fragment of any invertebrate in pellets was lowest during winter, although invertebrates still occurred in more than 80 percent of the pellet samples collected during this season. Among vertebrates, kangaroo rats and Perognathinae varied significantly in frequency of occurrence in owl pellets across seasons. Remains of reptiles, pocket gophers (*Thomomys* spp.), sagebrush voles, and shrews were not detected in pellets collected during fall or winter but were detected in pellets collected during spring and summer. Frequency of occurrence of any fragment of any rodent in pellets was lowest in the fall and lower in summer than in spring.

Overall, the results support the general premise of researchers in other areas. Owls on the NTS are opportunistic feeders and have a generalist feeding strategy, rather than focusing on only one or a few food types. Based on activity pattern data and the nocturnal habit of many of the owl's major prey items, it appears that owls on the NTS are primarily nocturnal hunters that find the preponderance of their larger prey items (e.g., rodents, scorpions, sun spiders) at night rather than during the day. This is not to say that they do not forage during the day because in all likelihood they do, but usually not for the larger prey items.

Disturbance effects were monitored to determine the size of buffer zones around burrows that would protect owls and their burrows and to determine their tolerance to different disturbance types (e.g., vehicular traffic, human activity near burrow). The mean flushing distance was similar for humans walking towards a burrow (31 meters [m]) and vehicles approaching a burrow (29 m). The minimum distance at which 90 percent of flushing responses would have been avoided was 59 m for walking and 55 m for vehicles. We recommend a buffer zone of 60 m around any active owl burrow within which human activity (e.g., walking, driving) should be limited.

Traffic rates were monitored at 16 and 18 owl burrow sites during 2000 and 2001, respectively. At these locations, seven and ten nest burrows produced young during 2000 and 2001, respectively. Traffic rate measured during these years varied from a low of 0.2 to a high of 617.4 vehicles per day. Combining data across years, there was no significant correlation ($r^2 = 0.12$) between number of young detected at nest burrows and traffic rate and distance to the nest burrow from the road. Likewise, no significant correlation ($r^2 = 0.07$) was evident between burrow use rate during the breeding season and traffic rate and distance to the burrow from the road. We found no significant correlations between burrow use rate and any type of disturbance within 400 m of the burrow sites. Types of disturbances examined were roads (dirt, paved, gravel), drill pads, or nearby elevated perches including power lines, poles, road signs, and mounds. Other factors such as prey availability, predation pressure, microhabitat preferences (e.g., percent bare ground, percent vegetative cover, and vegetation height around burrows) influence burrow use.

Winter burrow and ambient air temperature profiles were measured with temperature data loggers from December 19 97 to March 1998 and from December 1998 to March 1999 to (1) characterize the winter temperature profiles inside burrows of different types and depths and (2) determine the temperature difference between ambient air temperature and air temperature inside a burrow. Burrow depth does influence burrow temperature with deeper burrows having warmer average temperatures and shallower burrows having colder average temperatures. Latitude appears to influence the average burrow temperature more than depth or elevation.

Burrows provide a warmer and more thermally stable environment through the winter with the average internal temperature of all burrows measured being 3.3 degrees Celsius (°C) warmer than the ambient air temperature. The biggest difference between average burrow and ambient air temperature occurred in December (5.1 °C) and was least in March (0.2 °C). Data from this study was limited and it was difficult to determine if owls preferentially selected winter burrows that were warmer than other available burrows.

NNSA/NSO activities appear to have minimal negative effects on the owl. Only one owl has been documented to have been killed directly by an NNSA/NSO activity since 1990 when records of bird deaths began to be recorded. It was hit by a vehicle in October 2002. Only two burrows (unoccupied) are known to have been destroyed during project activities since 1979. In contrast, the owl appears to have benefited from the habitat features created by past NTS activities (e.g., emplacement of culverts and pipes, mound building, roadcuts). Nonetheless, careful management of this species and its habitat is still important, especially because its preferred breeding habitat is in areas most likely to be developed for new projects or to be remediated due to past disturbances. Owls should be monitored every three to five years using the TrailMaster® camera system to identify population trends. If the species is listed, more intensive sampling, including annual reproductive monitoring and perhaps banding individual owls may be initiated. Preactivity surveys will continue to be performed before any land-disturbing activities occur to protect owls and their burrows. A 60-m buffer will be established around active owl burrows to limit human activity inside this buffer zone. Locations of owls and their burrows will continue to be updated and input into our Microsoft® Access database as new locations are documented.

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1.0 INTRODUCTION

The western burrowing owl (*Athene cunicularia hypugaea*), hereafter referred to as owl, is one of seven subspecies of owls that occur in North and Central America (Ridgway, 1914; Peters, 1940; Haug et al., 1993). It is a relatively small, long-legged, ground-dwelling owl (Figure 1-1) found in flat, open grasslands, steppes, deserts, prairies, and agricultural lands throughout the Central and Western United States, south-central Canada, Mexico, and Central America.

Because of declines in the abundance of this species, owls were listed by the U.S. Fish and Wildlife Service (USFWS) as a candidate for classification as threatened or endangered under the Endangered Species Act. Although removed from that list in 1996 when the listing process for candidate species was revised, owls are still regarded as a National Bird of Conservation Concern by the USFWS (USFWS, 2002), and is protected under the Migratory Bird Treaty Act.

Figure 1-1. Western burrowing owl (Athene cunicularia hypugae) (Photograph by Derek B. Hall, March 22, 2000).

In Nevada, owls are classified as Protected by the state, and as a proposed Sensitive species by the U.S. Bureau of Land Management. It is a species of special concern in numerous western states (Washington, Oregon, California, Montana, Wyoming, Idaho, and Utah) and is regarded as declining in other states (California, Texas, Oklahoma, Kansas, New Mexico, and Nebraska) (Haug et al., 1993; Desante et al., 1997). Although data are sparse and perhaps insufficient, population trends for the owl in Nevada appear to be stable (Neel, 1999; Sauer et al., 2000; Klute et al., 2003). However, localized population decreases have been noted, especially in southern Nevada (Clark County), and in the Lahontan Valley. The statewide population was roughly estimated at 1,000 to 10,000 pairs in 1992 (James and Espie, 1997).

The U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office

(NNSA/NSO) operates the Nevada Test Site (NTS), and is committed to managing lands in a manner that protects the environment. In fact, two main goals of the *Nevada Test Site Resource Management Plan* (U.S. Department of Energy, Nevada Operations office [DOE/NV], 1998) are to: (1) protect and conserve significant biological resources and (2) minimize cumulative impacts to biological resources. Additionally, NNSA/NSO is committed to characterize trends in biological resources and determine the effects, if any, of NNSA/NSO activities on biological resources through the Ecological Monitoring and Compliance Program (EMAC).

This program includes monitoring owls because of this species' federal and state status. Also, compared to most other special status animal species on the NTS, the owl requires greater management attention because it occupies the flat, open valley bottoms where most ongoing activities are occurring and where most future activities are likely to occur. It may therefore be affected by activities occurring on the NTS. Potential future listing of this species as threatened or endangered may result in restrictions being placed on NTS activities in order to protect these owls. Therefore, owls were monitored to: (1) obtain data on the ecology and natural history of this species on the NTS, (2) determine what impacts, if any, NNSA/NSO activities have on this species, and (3) develop mitigation recommendations in the event the owl is ever listed under the Endangered Species Act.

This report summarizes data collected during owl monitoring from November 1997 to May 2002. Major sections include species distribution, burrow use monitoring, reproduction and activity patterns, food habits, disturbance effects, winter burrow temperature profiles, and species management. Also included are several appendices that contain much of the raw data collected during monitoring activities.

1.1 Study Area

The NTS (Figure 1-2) is located in south-central Nevada approximately 105 kilometers (km) northwest of Las Vegas. The NTS encompasses approximately 3,567 square km, and despite drastic changes to localized areas of the NTS due to nuclear testing activities for more than 40 years, biological resources over much of the NTS remain relatively pristine and undisturbed. NNSA/NSO estimates that only seven percent of the site has been disturbed (DOE/NV, 1996).

The southern two-thirds of the NTS is dominated by three large valleys or basins: Yucca, Frenchman, and Jackass flats. Mountain ridges and hills rise above sloping alluvial fans and enclose these basins. The northern, northwestern, and west central sections of the NTS are dominated by the Pahute and Rainier mesas and the Timber and Shoshone mountains. Elevation on the NTS ranges from less than 1,000 meters (m) above sea level in Frenchman and Jackass Flats to greater than 2,300 m on Rainier Mesa.

The NTS has a climate characteristic of high deserts with little precipitation, hot summers, mild winters and large diurnal temperature ranges. Monthly average temperatures in the NTS area range from 7 degrees Celsius (°C) in January to 32 °C in July (Wills and Ostler, 2001). The average annual precipitation on the NTS ranges from 15 centimeters (cm) at the lower elevations to 23 cm at the higher elevations (DOE/NV, 1996). About 60 percent of this precipitation occurs from September through March.

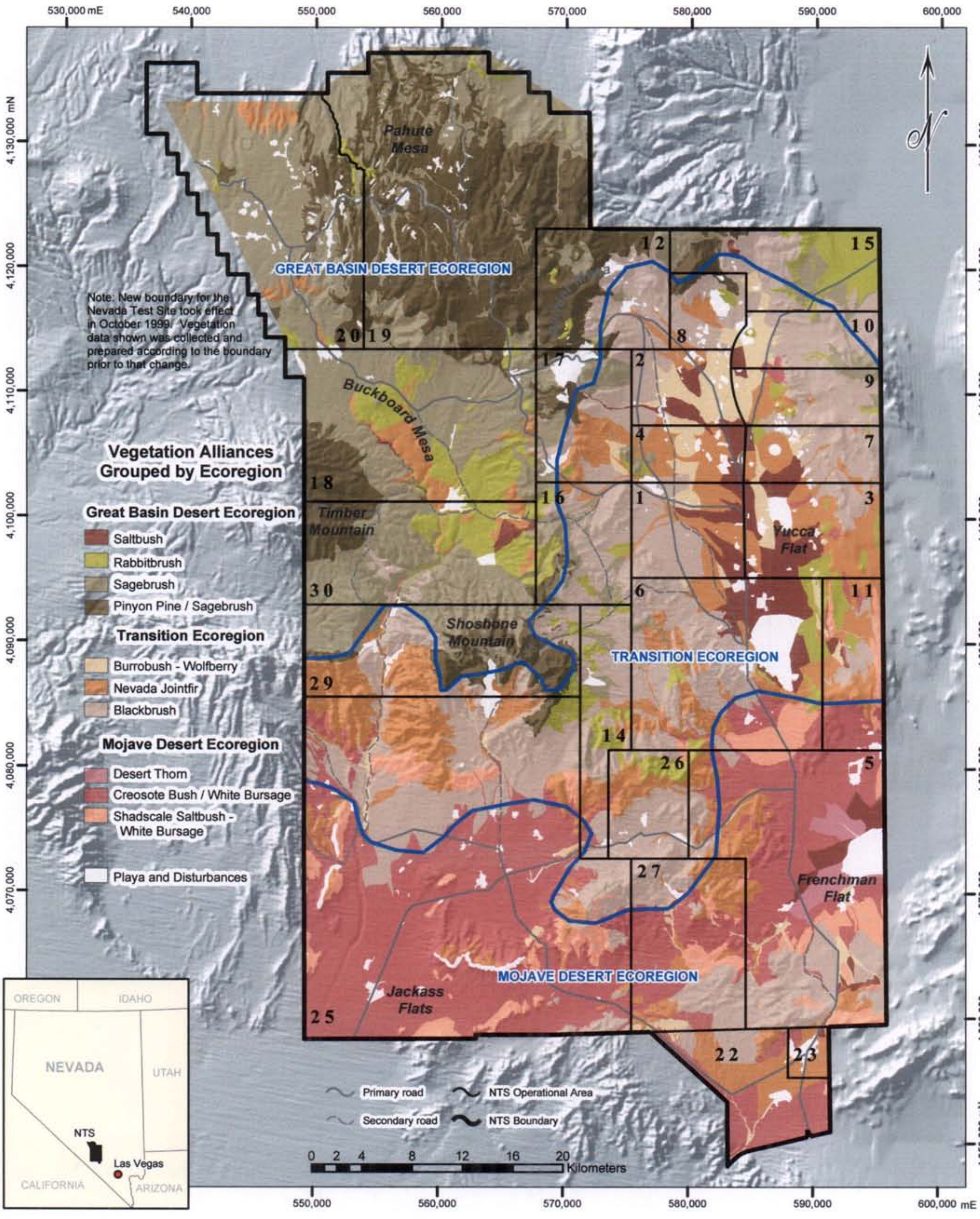

Figure 1-2. Major topographic features and vegetation alliances on the Nevada Test Site.

The NTS lies between the Great Basin Desert and the Mojave Desert as defined by Jaeger (1957). Within the site boundaries are found both of these desert types. Transitional areas between the two deserts are also present having been created by gradients in precipitation, elevation, temperature, and soils. Unique combinations of physical site conditions have resulted in several different vegetation alliances and associations (Ostler et al., 2000) (Figure 1-2). Based on these vegetation alliances, three distinct ecoregions occur on the NTS; namely, the Great Basin Desert, Mojave Desert, and transition ecoregions. The Great Basin Desert ecoregion is a cold desert with dominant plant species consisting of sagebrush species (*Artemisia* spp.), singleleaf pinyon (*Pinus monophylla*), and Utah juniper (*Juniperus osteosperma*). The Mojave Desert ecoregion is a hot desert with dominant plant species being creosote bush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*). The transition ecoregion is transitional between the Great Basin and Mojave Desert ecoregions with dominant plant species consisting of blackbrush (*Coleogyne ramosissima*), Nevada jointfir (*Epehdra nevadensis*), and burrobrush (*Hymenoclea salsola*). These three distinct ecoregions make the NTS a unique site and allow for comparisons of owl monitoring data among the three ecoregions.

2.0 SPECIES DISTRIBUTION

2.1 Introduction

Up until 1996, no studies on owls had been conducted on the NTS. However, numerous opportunistic sightings were recorded by biologists from 1961-1996 (Hayward et al., 1963; Hill, 1972, Hill and Burr, 1973; Castetter, 1975-1977 [unpublished field notes]; Greger, 1994; Greger and Romney, 1994a; Greger and Romney, 1994b; EG&G Energy Measurements, Inc. [EG&G/EM], 1995a; EG&G/EM, 1995b; EG&G/EM, 1995c; Greger, 1995; Woodward et al., 1995; DOE/NV, 1984-1996 [unpublished wildlife data]; Boone and Lederle, 1998). These data identified 41 unique owl locations. Owl locations include burrow sites (i.e., burrows with owl sign [e.g., owls, pellets]) and sighting locations (i.e., owl was seen but no burrow found). Burrow sites were documented at 18 of the 41 owl locations. All owl locations occurred within major flats and valleys in the eastern and southern portions of the NTS.

During the spring and summer of 1996, a study was initiated to determine the distribution of the owl on the NTS using a method adapted from Haug and Didiuk (1993) (Steen et al., 1997). This method entailed broadcasting a territorial call from a public address system at 250 call stops along roads throughout much of the NTS while listening for a response and visually searching for owls during the breeding season. Owls were detected at 12 call stop locations. Of these 12, 10 were new locations, making a total of 51 unique owl locations. Seven new burrow sites were located, making a total of 25 known burrow sites on the NTS through 1996.

Walking surveys and road surveys were initiated after 1996 to find additional owl locations and to determine if owls occurred on the NTS year-round. All new owl locations found after 1996 as a result of walking surveys, road surveys, burrow monitoring, and other activities are presented along with the historical locations in this section.

2.2 Methods

Walking surveys were conducted to locate new owl locations primarily away from roads. Surveys were conducted between November 1997 and June 2000. Approximately 10 km, 74 km, and 16 km were walked in the Great Basin Desert, Mojave Desert, and transition ecoregions, respectively. A total of 100 km were walked which took 53 hours to complete . One or two biologists walked meandering transects and visually searched for owls and burrows with owl sign (e.g., pellets, scat, feathers). Surveys were not conducted systematically; rather, biologists would look for areas with good owl habitat (e.g., areas with relatively deep washes, areas with pronounced dirt mounds) and walk through these areas. During these surveys, biologists searched a variety of habitats (e.g., washes, uplands). Biologists also reported owl sightings and burrows with owl sign while conducting other field work.

Road surveys entailed driving standardized routes in known owl habitat, stopping approximately every 2 km, and visually searching for owls with binoculars (10x). Road surveys were conducted on four dates: November 25 (1997), December 15 (1997), January 27 (1998), and March 4 (1998). A southern route, located primarily in the Mojave Desert ecoregion, was approximately 128 km in length, and a northern route, located in Yucca Flat in the transition ecoregion, was approximately 70 km in length.

Universal Transverse Mercator (UTM) coordinates were taken at most owl burrows and sighting locations using a hand-held global positioning system unit. Some of the historic sites were identified only by written descriptions. For most of these locations, UTM coordinates were estimated from U.S. Geological Survey topographic maps (Scale 1:24,000). In some cases, written descriptions were too general to estimate UTM coordinates. All coordinates were entered into a Microsoft® Access database and exported as a text file, from which a geographic information system (GIS) coverage was created using Environmental Systems Research Institute® Data Automation Kit software. This coverage was then loaded into Environmental Systems Research Institute® ArcGIS software and displayed to spatially depict owl distribution on the NTS.

It is important to note that we define a burrow site as one or more burrow openings occurring in the same microhabitat type (e.g., drill pad). A burrow opening or burrow is defined as a structure that contains an opening leading underground. Burrow openings were in soil (earthen), caliche, a metal culvert, or metal or plastic pipe. In some cases, the same pipe or culvert had two openings, and it was not determined if the pipe or culvert was open all the way through or not. Therefore, each burrow opening within a burrow site was documented and monitored.

The following data were recorded for each burrow site: number of burrow openings; burrow type (e.g., earthen, culvert, pipe); height, width, and aspect of burrow entrance; presence/absence and estimated age of owl sign; topographic position of burrow site (e.g., basin floor, piedmont slope); elevation; and vegetation association (Appendix A). Elevation (m) and vegetation association were also determined for sighting locations. Elevation was estimated by plotting the location's UTM coordinates on U.S. Geological Survey topographic maps (Scale 1:24,000) and recording the value of the contour line nearest to the plotted point. Vegetation information was obtained by plotting the owl locations in GIS and overlaying these locations with the GIS vegetation association map (Ostler et al., 2000).

2.3 Results

Sixty-four new owl burrow sites and four new sighting locations were documented between November 1997 and May 2002. A total of 89 burrow sites and 30 sighting locations are known to occur on the NTS (Figure 2-1). Of these 119 locations, 64 (54 percent) occur in the transition ecoregion, 38 (32 percent) occur in the Mojave Desert ecoregion, 11 (9 percent) occur in the Great Basin Desert ecoregion, and 6 (5 percent) are at unspecified locations. Owl locations on the NTS occurred primarily in areas with relatively deep washes with defined banks, mounds of dirt or excavations, disturbances containing partially buried metal culverts and pipes, or roadcuts. The average elevation of owl locations on the NTS is 1,265 m (range 866-1905 m; standard deviation [s.d.] 190 m). Owl locations occur in 12 of the 21 different vegetation associations found on the NTS (Ostler et al., 2000) (Table 2-1).

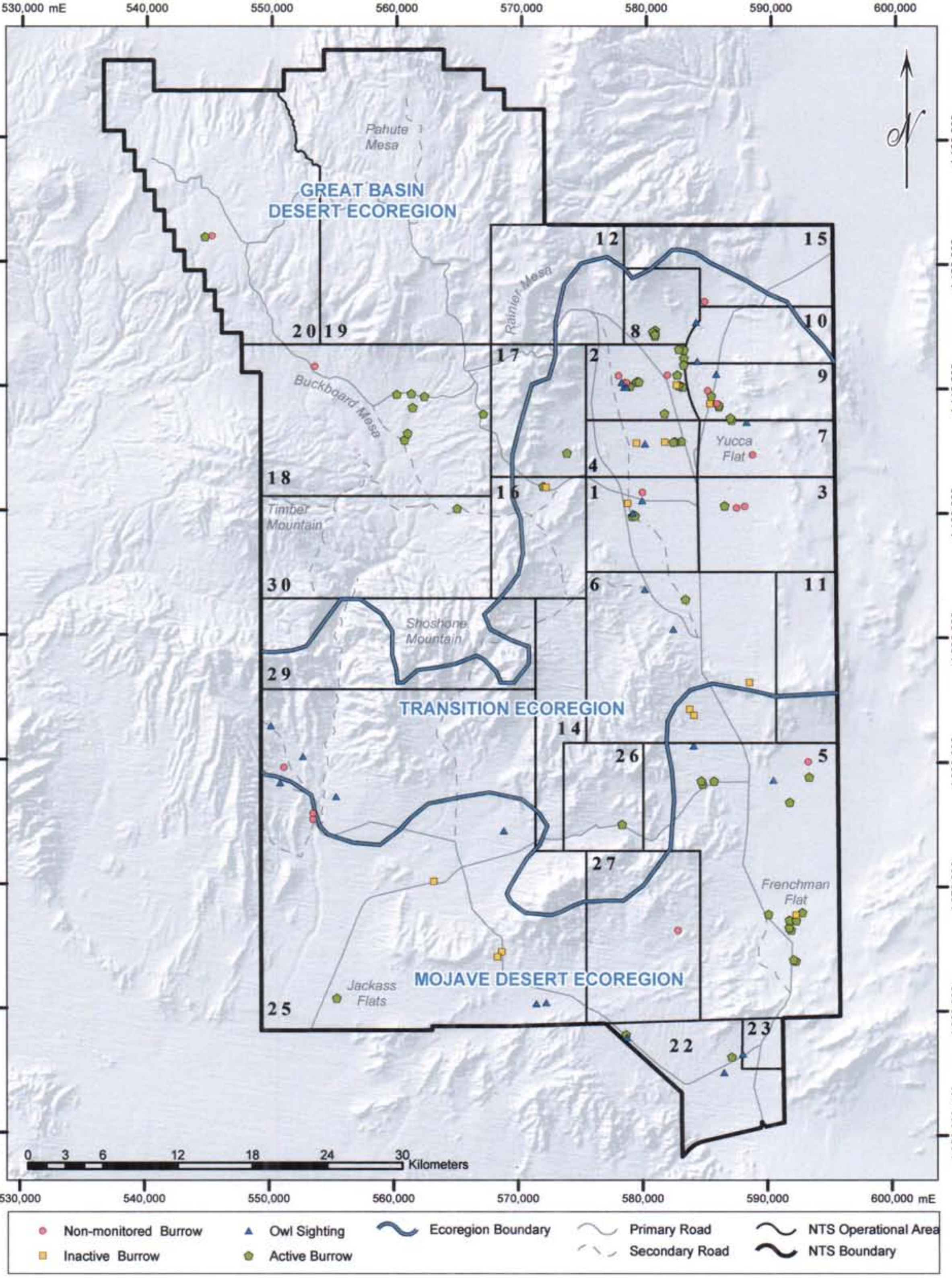

Figure 2-1. Known owl distribution on the Nevada Test Site.

Table 2-1. Number of owl locations in each vegetation association and the areal extent (i.e., percent of total area) of each vegetation association occurring on the Nevada Test Site.

Vegetation Association	Number of owl locations	Areal extent (% of total area)
Hymenoclea salsola-Ephedra nevadensis Shrubland	26	2.0
Larrea tridentata/Ambrosia dumosa Shrubland	24	18.0
Other (Miscellaneous vegetation, playas, mapped disturbances)	14	1.5
Coleogyne ramosissima-Ephedra nevadensis Shrubland	13	21.6
Ephedra nevadensis-Grayia spinosa Shrubland	14	5.9
Artemisia tridentata-Chrysothamnus viscidiflorus Shrubland	7	7.3
Atriplex confertifolia-Ambrosia dumosa Shrubland	6	3.4
Menodora spinescens-Ephedra nevadensis Shrubland	3	2.5
Atriplex confertifolia-Kochia americana Shrubland	2	0.9
Atriplex canescens-Krascheninnikovia lanata Shrubland	2	2.2
Krascheninnikovia lanata-Ephedra nevadensis Shrubland	1	1.2
Lycium shockleyi-Lycium pallidum Shrubland	1	0.4
Ericameria nauseosa-Ephedra nevadensis Shrubland	0	0.8
Lycium andersonii-Hymenoclea salsola Shrubland	0	0.4
Eriogonum fasciculatum-Ephedra nevadensis Shrubland	0	3.0
Chrysothamnus viscidiflorus-Ephedra nevadensis Shrubland	0	4.8
Ephedra viridis-Artemisia tridentata Shrubland	0	2.5
Artemisia nova-Chrysothamnus viscidiflorus Shrubland	0	6.9
Artemisia nova-Artemisia tridentata Shrubland	0	1.4
Pinus monophylla/Artemisia nova Woodland	0	7.4
Pinus monophylla/Artemisia tridentata Woodland	0	5.9
TOTAL	113*	100.0

*=six are at unspecified locations

Thirteen new burrow sites were found during 36 walking surveys. Ten new burrow sites were found in the Mojave Desert ecoregion, three were found in the transition ecoregion, and none were found in the Great Basin Desert ecoregion. Approximately 1.3 burrow sites/10 km were found, and areas were sampled at a rate of approximately 1.9 km/hour. Fifty-one new burrow sites and two new owl locations were recorded while conducting other field work (e.g., burrow monitoring (Section 3.0), habitat mapping, preactivity surveys).

During the road surveys only two owl sightings were recorded on the northern route, one on November 25 around dusk and one on December 15 one hour before dusk. This is important because it showed that owls occur on the NTS year-round. No owls were seen on the southern route.

2.4 Discussion

The known distribution of owls on the NTS (Figure 2-1) is based on historical data and new data which include opportunistic sightings, road surveys with and without the territorial call playback, and walking surveys in areas considered to be good owl habitat. It is not based on a uniform sampling of all vegetation associations on the NTS, although some sampling has occurred in each of the vegetation associations.

The greatest number of owl locations occurs within the *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association (Table 2-1). This vegetation association only occupies 2.0 percent of the NTS area and is associated with disturbed areas where much of the historic nuclear testing occurred. Owls appear to be selecting for this disturbed habitat where there are open areas with numerous culverts and pipes with scattered perennial and abundant annual vegetation. Several owl locations also occur in areas designated as "other" which occupies only 1.5 percent of the NTS area. Owl locations in "other" areas occurred in mapped disturbances or miscellaneous vegetation types. No other specific preferences for vegetation association are evident given the distribution of owl locations documented to date.

A little over half (63 of 117) of all owl locations occur in the transition ecoregion, with most of these (58 of 63) being in Yucca Flat (Figure 2-1). This is most likely due to the abundance of partially buried culverts and pipes left over from historic nuclear testing activities that were concentrated within Yucca Flat. These culverts and pipes appear to provide a suitable burrow where owls can live and reproduce. Furthermore, much of the area around these human-made burrows is heavily disturbed with scattered perennial vegetation and abundant annual plants resulting in an open habitat. The openness of the habitat probably increases the owls' ability to detect predators and is also known to support prey species eaten by owls (see Section 5.4).

About one-third (37 of 117) of the locations occur in the Mojave Desert ecoregion. Thirteen of the 26 burrow sites (50 percent) in this ecoregion are associated with washes. In northern and central Frenchman Flat, transect surveys were conducted in 2001 to detect sensitive species and important biological resources along routes where off-road driving and seismic experimentation would occur. Approximately 256 km were walked and no owl burrows were found (Bechtel Nevada, 2001). The transects were in areas that ranged from gradually sloping terrain to a barren playa with none to few relatively deep washes. In contrast, surveys conducted in south Frenchman Flat in an area dissected with numerous relatively deep washes yielded six burrow sites over 18 km walked. Thus, it appears that areas with suitable wash habitat have higher concentrations of owl burrows than gradually sloping bajadas or valley bottoms. This does not mean that owl burrows can't be found on gradually sloping bajadas or valley bottoms, but they tend to be more sparsely distributed in these areas on Frenchman Flat.

Only nine percent (11 of 117) of the owl locations occur in the Great Basin Desert ecoregion. The discovery of these locations greatly expanded the known distribution of this species on the NTS. Steen et al. (1997) conducted call stop surveys in the Great Basin Desert ecoregion but did not detect any owls. Most of the new burrow sites found are located in roadcuts in areas dominated by basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*).

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3.0 BURROW USE

3.1 Introduction

Numerous studies have been conducted on burrow use by owls in the Western United States and Western Canada (Thomsen, 1971; Coulombe, 1971; Martin, 1973; Wedgwood, 1976; Henny and Blus, 1981; Rich, 1984; MacCracken et al., 1985a; Rich, 1986; Green and Anthony, 1989; Plumpton and Lutz, 1993; Belthoff and King, 1994; Belthoff et al., 1995; Botelho and Arrowood, 1998; Belthoff and Smith, 2000; Belthoff and Smith, 2003). Some of these studies have documented the use and reuse of individual burrows over multi-year periods (Martin, 1973; Wedgwood, 1976; Rich, 1984; Plumpton and Lutz, 1993; Belthoff and King, 1994; Belthoff and Smith, 2000; Belthoff and Smith, 2003). These studies have shown that burrow use varies greatly among studies and between locations and years. Since some burrows may be used more frequently or consistently than others, their loss might have a greater local impact on the species than the loss of infrequently used burrows in the same region. Additionally, little information is available on burrow use during the winter (Coulombe, 1971; Butts, 1976). Historically on the NTS, owls were reported to be year-round residents (Hayward et al., 1963; Hill and Burr, 1973; O'Farrell and Emery, 1976), but there was no data to support this conclusion (Steen et al., 1997). Specifically, there was no documentation of owls occurring on the NTS during the months of November and December. In order to determine which burrow sites were used the most and seasonal patterns of use (e.g., year-round residency status and timing of immigration and emigration), burrows were monitored on the NTS from 1997-2001 in each of the three ecoregions.

3.2 Methods

Monitoring was conducted at known owl burrows approximately every two weeks from November 1997 through March 1998 to determine if owls were found on the NTS during winter. Monitoring of some burrows continued infrequently through July. Monthly monitoring of known burrows began in November 1998 and continued through December 2001 except for the period February through April 1999 when monitoring was again done approximately every two weeks to better determine the timing of owl immigration to the NTS. When monitoring was initiated, burrows were selected from opportunistic sighting data from 1961-1996 (see references in 2.1 Introduction) and from primary call stop surveys from 1996 (Steen et al. 1997). As monitoring progressed, new burrows were found and added to the monitoring schedule. Also, the number of sites sampled did not remain constant for the following reasons: new burrows were found, some burrows were filled in, and some burrows were not visited when there were time or access constraints.

During each visit to a burrow site, the presence of any owls was recorded. In addition, the burrow apron of each burrow and the first 30 cm inside the burrow were searched for the presence of owl sign (i.e., pellets, scat, feathers, tracks, prey remains) and any sign found was documented and then removed. On the next visit, we recorded the presence/absence of any new owl sign, including owls, at each burrow. New sign indicated that owls occupied the burrow at some time since the previous visit. A burrow site was considered active if one or more individual burrows or burrow openings had fresh sign or owls were observed nearby. Each burrow was categorized as to occurring in natural (e.g., wash) or human-altered (e.g., roadcut, mound) habitat and then classified what type of burrow it was (e.g., earthen, culvert). Also recorded was the aspect (degrees), height and width of each burrow entrance (cm), microhabitat type (e.g., wash, drill-pad, roadside), and the number of burrow openings. Culverts were metal, semi-circular structures that had been inserted into the ground, usually at road crossings, to protect buried cables at old NTS project sites. Pipes were circular, metal or plastic structures at old project sites that were inserted into the ground usually with at least one opening exposed to the surface. Each burrow was also photographed (see Appendix A).

For each active burrow site monitored for at least seven months, a burrow use rate (BURS) was calculated as:

$$BURS = M_D / M_M \times 100,$$

where M_D is the number of months when owls or fresh sign were detected at the burrow site (including the original visit when sign was found), and M_M is the total number of months that burrow site was monitored.

For each month and each ecoregion a burrow use rate (BURM) was calculated as:

$$BURM = B_A / B_M \times 100,$$

where B_A is the number of burrow sites that are active during any one month in an ecoregion and B_M is the number of burrow sites monitored that month in the ecoregion. BURM was calculated on data collected from November 1997 through December 2001.

For each calendar year from 1999 to 2001 a burrow reuse rate (BRR) was calculated as:

$$BRR=B_{AM}/B_{1998}$$

where B_{AM} is the number of burrow sites active in at least one month of each calendar year and B_{1998} is the number of active burrow sites in 1998.

Analysis-of-variance (general linear model; Minitab software version 12) was used to determine if significant ($p=0.05$) differences in BURS among ecoregions and burrow types were evident. Tukey's mean separation procedure (Minitab version 12) was used to determine which BURS values were significantly different from each other at $\alpha=0.05$. Percentage data were arcsin transformed before the analysis to normalize the dataset (Brownlee, 1965).

3.3 Results

A total of 172 burrow openings at 79 burrow sites were located and measured on the NTS between November 1997 and May 2002. Appendix A contains complete descriptive data and photos for these burrows. Of the total openings and sites located, a maximum of 164 owl burrows at 71 burrow sites were routinely monitored between November 1997 and

December 2001 (Table 3-1). The number of burrows monitored increased over the monitoring period as new burrows were found.

3.3.1 Burrow Characteristics

A total of 120 burrows in human-altered habitat and 44 burrows in natural habitat were monitored for owl use. Of the 120 burrows in human-altered habitat, 75 were culverts, 22 were pipes, and 23 were earthen (Table 3-1). Earthen burrows in human-altered habitat are mostly found in road-cuts and the rest are in mounds, ditches, or an open pit. Of the 44 burrows in natural habitat, 24 are wash burrows and 20 are non-wash burrows. The largest number of culvert and pipe burrows (94 of 97) is located in the transition ecoregion (Table 3-1) with all of these occurring in Yucca Flat. Most of the natural burrows (33 of 44) are located in the Mojave Desert ecoregion, while most road-cut burrows (11 of 15) are in the Great Basin Desert ecoregion (Table 3-1).

Table 3-1. Types of owl burrows by habitat and ecoregion monitored for owl use on the Nevada Test Site (November 1997 to December 2001).

Burrow Types		Ecoregion				
		Great Basin	Mojave	Transition	Total	%
NATURAL HABITAT						
Non-Wash Earthen Burrows		0	15	5	20	12.2
Wash Earthen Burrows						
Caliche		0	5	4	9	5.5
Alluvial		1	13	1	15	9.1
Total		**1**	**33**	**10**	**44**	**26.8**
HUMAN-ALTERED HABITAT						
Culvert Burrows						
Culvert Near Roads		0	0	52	52	31.7
Culvert on Pad		2	0	21	23	14.0
	Total	2	0	73	75	45.7
Pipe Burrows						
Pipe Near Roads		0	1	8	9	5.5
Pipe on Pad		0	0	13	13	7.9
	Total	0	1	21	22	13.4
Earthen Burrows						
Road-cut		11	0	4	15	9.1
Mound		0	1	3	4	2.4
Ditch		0	0	3	3	1.8
Open Pit		0	1	0	1	0.6
	Total	11	2	10	23	14.0
Total		**13**	**3**	**104**	**120**	**73.2**
TOTAL ALL BURROWS		**14**	**36**	**114**	**164**	

Twenty burrows monitored over 4 years were filled in with sediment and became unusable by owls. Eighteen (90 percent) of these were earthen burrows: 12 of these were in natural habitat and 6 were in human-altered habitat. Two earthen burrows out of 20 that became unusable by owls were filled in with vegetation by packrats. One additional earthen burrow was filled in with soil by an animal (for 5 months) and was later reopened; owls reproduced there after it was reopened. During this same period, only two (10 percent) culvert burrows became filled in. Sixteen burrows that were monitored were tortoise burrows that at some time during the study were used intermittently by owls.

The frequency distribution of the number of burrow openings at burrow sites is shown in Figure 3-1. A large proportion (71.8 percent) of the sites monitored had one or two burrow openings (range of 1-11). There was no strong relationship (r^2=0.12) between the number of burrow openings at a site and the BURS.

Table 3-2 contains the height and width data for the different burrow types. Pipe burrows had the narrowest ranges of both height and width and narrowest average width compared to earthen and culvert burrows (Table 3-2). Earthen burrows had the largest range of widths.

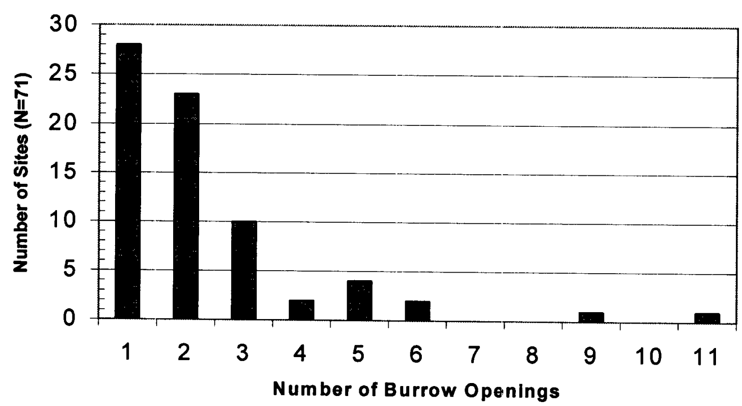

Figure 3-1. Frequency distribution of the number of burrow openings at burrow sites monitored on the Nevada Test Site between November 1997 and December 2001.

Table 3-2. Average height and width measurements for burrow openings (n=162) monitored on the Nevada Test Site between November 1997 and December 2001 (two burrows were not measured).

Burrow Type	Range (cm)	Average (cm)	Standard deviation (cm)	Sample size (n)
Burrow Height				
Culvert	7-31	18.7	5.8	75
Earthen	8-33	16.5	5.5	65
Pipe	9-17	14.2	2.2	22
Burrow Width				
Culvert	14-48	34.3	5.5	75
Earthen	12-120	34.2	18.1	65
Pipe	14-20	15.9	1.5	22

3.3.2 Burrow Use Rate by Burrow Site

Detailed monthly burrow use by burrow site is presented in Appendix B. BURS values with corresponding raw data are found in Appendix C. A total of 71 burrow sites were monitored. Of these, 22 were classified as culvert burrow sites, 7 were culvert and pipe burrow sites, 1 was a pipe burrow site, 16 were earthen burrow sites in human-altered habitat, and 25 were earthen burrow sites in natural habitat. Active owl use (owls present or fresh sign) was detected at 58 of 71 (81.7 percent) sites monitored. Two of the active sites were found late in the monitoring period and only monitored for a few months. The remaining 13 sites had only old owl sign (e.g., pellets) of indeterminate age when we began monitoring and afterwards never had new, fresh sign.

Overall, the mean BURS for 56 active burrow sites on the NTS was 28.8 percent. BURS values were highly variable and ranged from 3 to 100 percent. No significant (p=0.33) differences were found for BURS values among ecoregions (Figure 3-2). However, significant (p=0.01) differences were detected for BURS values among burrow types, with culvert and pipe burrow sites having higher BURS values than the other three burrow site categories (Figure 3-3).

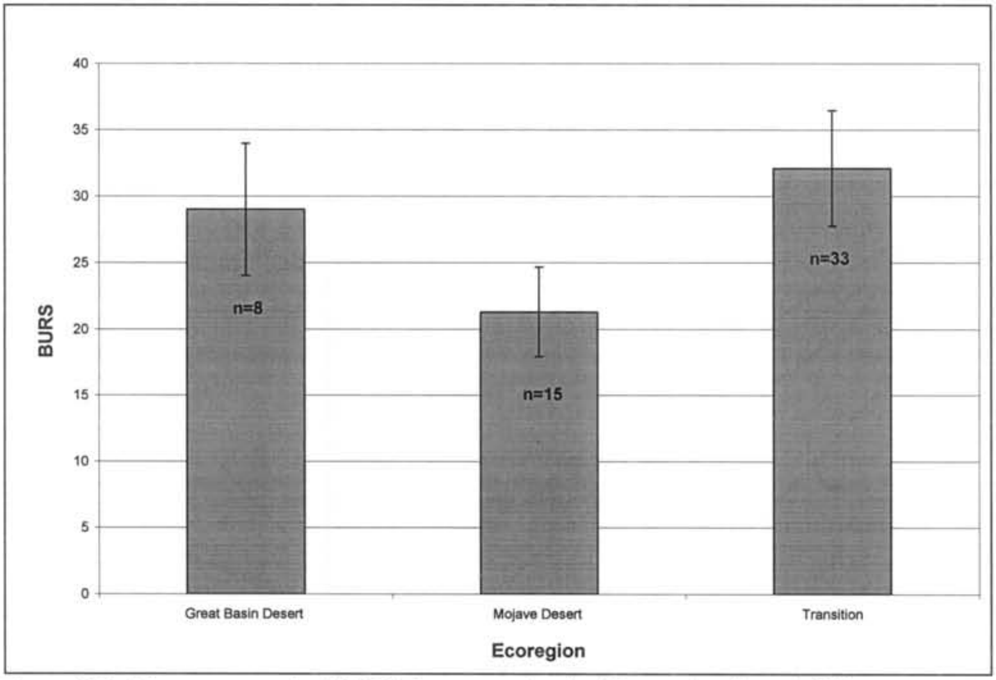

Figure 3-2. Burrow use rate (BURS) by ecoregion (n=56; no significant differences among ecoregions).

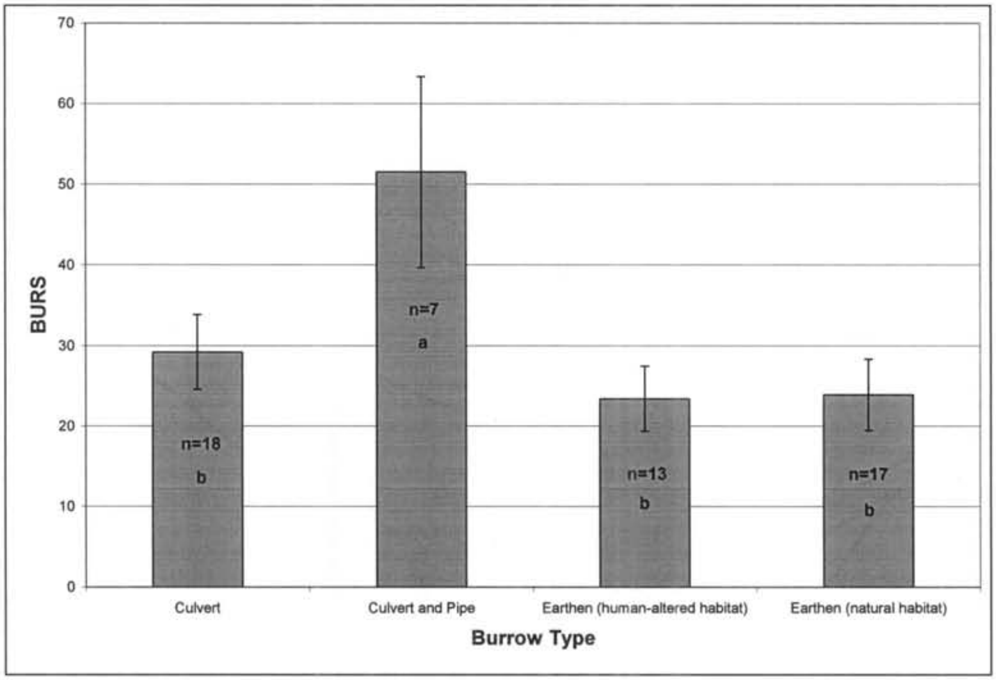

Figure 3-3. Burrow use rate (BURS) by burrow type (n=55; Site #19 was excluded due to a sample size of one; different letters indicate significant differences at α=0.05).

3.3.3 Burrow Use Rate by Month and Ecoregion

BURM values are shown for the duration of the monitoring period in Figure 3-4 with corresponding raw data presented in Appendix D. Results indicate that owls occur on the NTS year-round. The Great Basin Desert ecoregion had highest overall BURM values during 1998-2000, although only one to seven sites were sampled. The use rate in this ecoregion dropped to zero in the spring of 2001 and remained at zero through the end of the monitoring period. BURM values in the transition ecoregion were generally higher than in the Mojave Desert ecoregion.

Each ecoregion shows a similar pattern each year: BURM values decline during December to February followed by an increase during March to May. BURM values in the Mojave Desert ecoregion also increase each year in September. Owls were present on the NTS during winter (December-February) and BURM values were generally at their lowest point during this time. Overall, owls used 33 burrow sites during winter (December-February) at the NTS for at least one or more month's duration. Winter rates of burrow occupancy varied greatly (0-67 percent), between regions, months, and years and often dropped to below 15 percent or lower in each ecoregion during January or February (Figure 3-4, Appendix D).

3.3.4 Burrow Reuse Rate

The BRR value steadily declined each year over the monitoring period. Of the original 29 burrows active in 1998; 23 of 29 (79.3 percent) were reused during 1999, 18 of 27

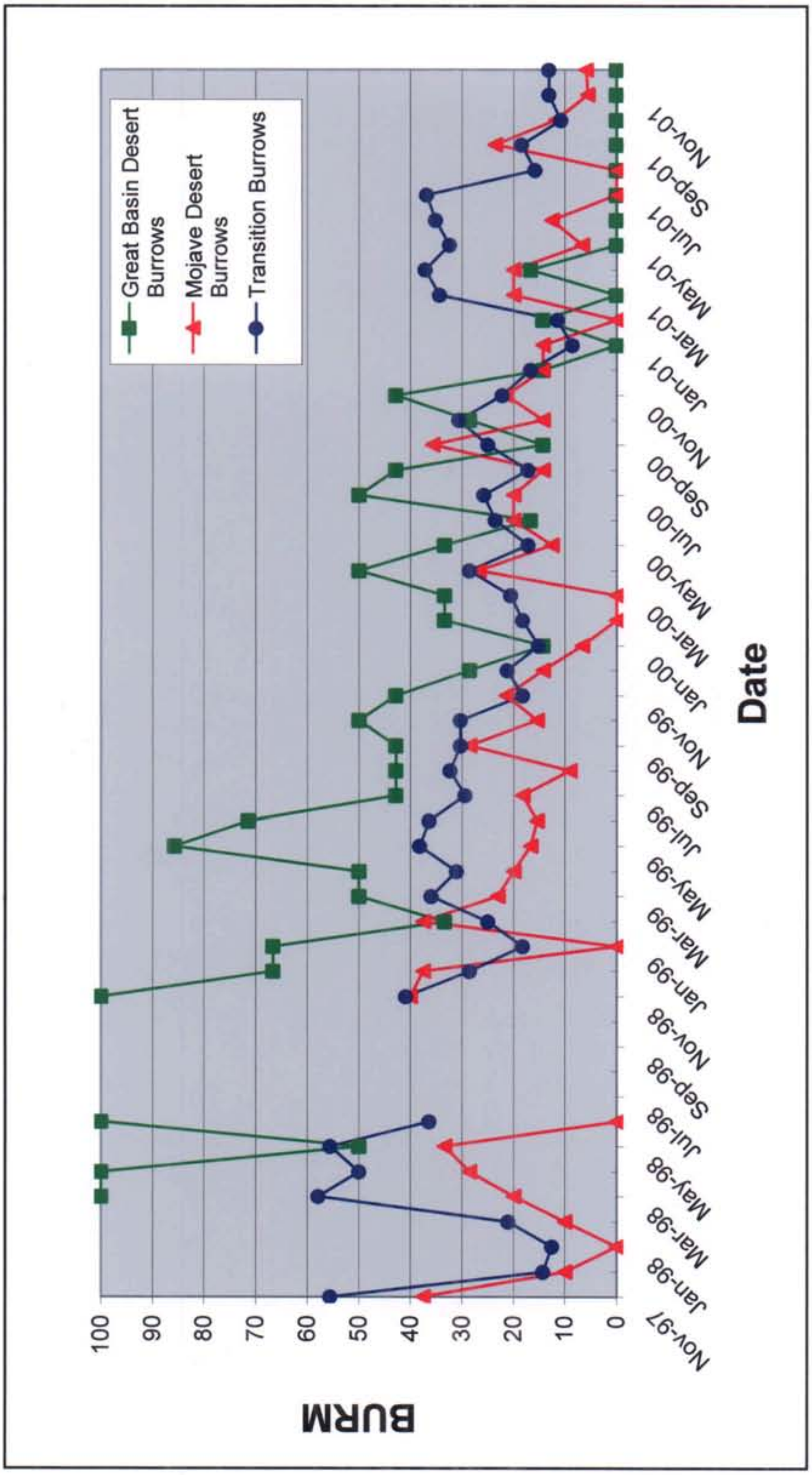

Figure 3-4. Burrow use rate by month and ecoregion (BURM) from November 1997 to December 2001.

(66.7 percent) (two of the original burrows were filled in) were reused during 2000, and 14 of 27 (51.9 percent) were reused during 2001.

3.4 Discussion

3.4.1 Burrow Characteristics

Burrow monitoring on the NTS shows that burrows in human-altered habitat account for nearly three-fourths of all known burrows on the NTS while burrows in natural habitat account for roughly one-fourth. Thus, DOE activities such as emplacing culverts and pipes, road building, digging pits and channels, and mound building have benefited the owl directly by increasing the number of useable burrows and indirectly by altering the natural habitat so it is more suitable for owls (e.g., increased opportunities for predators to dig burrows in altered soil, more open habitat). Culvert burrows maintained openings longer over time compared to earthen burrows, which have a tendency to cave in or fill in more rapidly over time.

3.4.2 Burrow Use Rate by Burrow Site

No significant differences were found for BURS values among ecoregions. Significant differences were detected among burrow types with burrow sites containing both culverts and pipes having a higher use rate than culvert burrows, earthen burrows in human-altered habitat, or earthen burrows in natural habitat. There were only seven sites on the NTS (all in the transition ecoregion [Yucca Flat]) that had mixtures of culvert and pipe burrows. Six out of seven sites with culverts and pipes were on drill pads. Perhaps, owls prefer the habitat where these culvert and pipe sites are located and not the culverts and pipes themselves. Drill pad sites typically have sparse vegetation comprised mostly of native and introduced annual forbs and grasses with little native perennial vegetation. Zarn (1974) lists three essential factors for good burrowing owl habitat; openness, short vegetation, and burrow availability (Best, 1969; Butts, 1973; Coulombe, 1971). Owls are also known to select areas with more bare ground and less grass cover than the surrounding area (MacCracken et al., 1985a; Green and Anthony, 1989; Plumpton and Lutz, 1993; Belthoff et al., 1995). More bare ground and lower vegetation may increase an owl's ability to detect predators and allow for more efficient predation by owls on their mammalian prey.

Use rates among culvert burrow sites, earthen burrows in human-altered habitat, and earthen burrows in natural habitat were relatively equal. This suggests that owls did not use one of these burrow types more than another. Other factors such as prey availability, vegetation height, etc. are important to an owl in its selection of a suitable burrow. Internal burrow characteristics (e.g., depth, length, architecture) are likewise important suitability factors that should be investigated in future studies.

3.4.3 Burrow Use by Month and Ecoregion

Burrow monitoring showed that owls are present on the NTS year-round and the timing of immigration and emigration in the different ecoregions. Whether or not the same owls resided on the NTS year-round is not known because individual owls were not banded. BURM values indicate increased use from March to May which suggests that owls were immigrating to the NTS during this time period. BURM values then generally decreased at various rates to their lowest point during December to February. An exception to this general use pattern occurred in the Mojave Desert ecoregion. During September, BURM values increased sharply and dropped again in October. This spike in use may have been due to dispersing juveniles searching for their own burrows or from migrating owls that used burrows in this ecoregion as stopover points as they headed south. The peak of use in the spring may have been from resident or migrating owls that were searching for suitable breeding burrows or from migrating owls just passing through on their way northward. Burrow monitoring also showed which burrows were used more consistently than others which will allow us to protect these important burrows.

3.4.4 Burrow Reuse Rate

Most studies conducted on owl burrows reported in the literature involved short term monitoring (1-2 years) and were concerned with only a select number of burrows to study owl behavior, nest fidelity and reproduction. A long-term study conducted over 7 years by Rich (1984) in Idaho found that owl reuse of burrows declined and stabilized roughly after a 3-to 4-year period. The burrow use rates documented by Rich (1984) from burrows initially discovered and monitored during subsequent years showed a percent decrease in reuse from the first year of occupancy to 47 percent a year later, 44 percent 2 years later and 23 percent 3 years later. On the NTS, results of burrow reuse over 4 years shows a similar pattern of change but with a lesser magnitude of decline. Our criteria of occupancy (a burrow site occupied at least one month per year was considered reused) may be different from Rich's criteria. This decline in burrow reuse may have an impact on a long-term monitoring program.

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4.0 REPRODUCTION AND ACTIVITY PATTERNS

4.1 Introduction

Owl reproduction on the NTS was first documented in June 1990, when a biologist observed a family group of four individuals at a burrow in north Yucca Flat (Greger and Romney, 1994b). Ten additional opportunistic sightings of groups numbering more than two individuals were seen between June 1990 and June 1999, when reproductive monitoring began. For this study, it was assumed that a family group consisted of three or more individual owls observed at a burrow site during the breeding season, unless the number of juvenile owls was specifically noted. The objectives of reproduction monitoring were to (1) describe nest burrow location, type, and use over time, (2) quantify the number of owl breeding pairs and young and timing of reproduction on the NTS, (3) evaluate the use of remote monitoring of occupied burrows for identifying owl population trends on the NTS, and (4) describe the activity patterns of owls based on photographs and event data.

Remote reproduction monitoring was conducted using active infrared beam and camera technology, specifically the TrailMaster® camera system (Goodson and Associates, Inc., Lenexa, Kansas), to document the number of breeding pairs and young. Other researchers have documented numbers of owl breeding pairs and young by direct visual counts outside burrows (Butts, 1971; Thomsen, 1971; Smith and Murphy, 1973a; Martin, 1973; Wedgwood, 1976; Gleason and Johnson, 1985; Ratcliff, 1986; Green and Anthony, 1989; Plumpton and Lutz, 1994; Belthoff and King, 1994; Botelho and Arrowood, 1998; Lutz and Plumpton, 1999; Millsap and Bear, 2000; Belthoff and Smith, 2000; Conway and Simon, 2003; Gorman et al., 2003), direct capture (Plumpton and Lutz, 1994), or observing them inside artificial nest burrows (Henny and Blus, 1981; Botelho and Arrowood, 1998; Belthoff and Smith, 2000; Todd et al., 2003). The TrailMaster® technique was selected over visual observations because numerous (five to seven) visits are needed to maximize the probability of detecting all young present at a given burrow (Henny and Blus, 1981; Gleason and Johnson, 1985; Gorman et al., 2003). The TrailMaster® technique only requires one to three visits and records owls at burrows over a longer time period than direct observations (e.g., up to 35 observations over an 18-hour period if photographs are taken every half hour). Use of the TrailMaster® camera systems to count owl breeding pairs and young has not been documented. TrailMaster® systems have been used by other researchers to identify ground-nest predators (Hernandez et al., 1997) and to inventory a wide variety of animals in many different habitats in California (Kucera and Barrett 1993).

The photographs and event data were examined to investigate daily activity patterns defined as presence on the burrow apron, prey delivery or feeding at burrow apron, and entry into or exiting from the burrow entrance. This was not an attempt to develop activity budgets for owls because of the technique limitations. The main reasons for analyzing activity patterns were to answer the following questions: (1) when are the best times to count the maximum number of young per nest burrow, (2) when do owls deliver prey to or feed themselves or others, (3) are there differences in activity patterns between young and adults, and (4) when are owls most active at their burrows.

Activity patterns of owls at their burrows have been previously reported (Grant, 1965; Coulombe, 1971; Thomsen, 1971; Marti, 1974; Zarn, 1974; Haug and Oliphant, 1990; Haug et al., 1993). Activity patterns in these studies were determined mainly by visual observations. In addition to visual observations, Marti (1974) used event recorders and Haug and Oliphant (1990) used radiotelemetry.

4.2 Methods

Known owl burrow sites were monitored monthly from February to August in 1999, 2000, and 2001 to determine active use by owls (see Section 3.2). TrailMaster® camera systems (Model TM1500) were then set up at each active burrow to photographically record owls using that burrow. Some burrow sites had multiple burrows. Where it appeared that a culvert or pipe had two entrances, a TrailMaster® system was set up at each entrance simultaneously. When more than two entrances occurred, TrailMaster® systems were usually set up at the entrances where fresh sign had been detected. One TrailMaster® system was used between June 3 and July 30, 1999. Two TrailMaster® systems were used from July 30 to September 9, 1999; February 22 to August 10, 2000; and April 25 to August 20, 2001. Burrows were sampled photographically from one to seven times (generally two to four) per year depending on how long a burrow remained active.

Each TM1500 system (Figure 4-1) consisted of an infrared transmitter (A), a receiver (B), a 35-mm, weather-resistant camera with protective shelter mounted to a fence post (C), and a cable connecting the camera to the receiver (D). The transmitter emits an infrared light beam that is aimed at a window on the side of the receiver, thus creating a beam of infrared light that the owl is unable to see. The transmitter and receiver were set up at a burrow entrance so that the beam of light projected across the entrance. Each time the beam of light was broken by an owl or other animal it was recorded as an event. The receiver recorded the date and time of each event. Each event could also trigger the camera to take a picture depending upon how the camera system was programmed. Two settings allowed for custom adjustment of (1) the length of time the beam must be broken to register as an event and (2) the minimum length of time between photographs. We used 0.5 seconds for the first setting and 30 minutes for the second. Thus, not every event was recorded on film, only those events that were at least 30 minutes apart from one another. The fence post, to which the camera was mounted, was positioned approximately 4 to 6 m from the burrow entrance and was aimed so the burrow entrance was in the center of the camera's field of view. Rolls of 200-speed, 36-exposure Kodak® Royal Gold film were used. Cameras were equipped with an automatic flash for night pictures.

Once the camera system was in place, the system was tested by manually interrupting the beam of light with a hand or other object and observing that the camera took a picture. The location, date, time, starting picture, frame number, and starting event number were recorded during initial setup at each burrow entrance. If, upon retrieving the system, the number of pictures taken was 10 or less, the film was left in the camera for the next site. Thus, the maximum number of pictures that were taken at any one burrow ranged from 25 to 35. The length of time the camera could take pictures at each burrow ranged from a minimum of 12.5 hours (25 pictures taken every half hour) to the entire duration of the setup. Thus, the "sampling effort" for photographs was not standard across burrows and was affected by the entry/exit behavior and number of owls

Figure 4-1. Trailmaster® (TM1500) camera system set up at Burrow Site #32 (A=transmitter, B=receiver, C=camera and protective shelter, and D=cable).

at each burrow. The maximum number of events that could be recorded was about 1,100 due to the memory storage limitations of the receiver.

TM1500 systems were moved to new burrows usually every two to three days. A portable data recorder was used to upload event data from the receivers in the field. These data were taken back and uploaded onto a desktop computer. The cameras were set up to print the date and time on the picture, and the times on both the camera and TM1500 receiver were synchronized. The film was processed commercially and each picture was labeled with the date, time, location, and what animal(s) was in the picture. Pictures were analyzed visually to determine numbers of adult and young owls. Young were distinguished from adult owls by coloration, presence of gray-downy feathers and/or white wing stripes, size, and lack of barring patterns (Bent, 1938; Thomsen, 1971; Haug et al., 1993). Numbers of breeding pairs and young were summarized. Also, the presence of other species was recorded. A breeding pair of owls was defined as a pair that had one or more young present at a burrow. A nonbreeding pair was defined as a pair of owls with which no young were detected. The number of young per breeding pair was defined as the maximum number of young detected in any single photograph, and does not necessarily reflect the number of young fledged. A nest burrow was defined as a burrow site where young owls were detected photographically with two exceptions: (1) burrows at which older young were first detected photographically late in the breeding season were not considered nest burrows because it was assumed that these young owls moved to these burrows from other areas and (2) one site (#64) had two breeding pairs and thus two nest burrows during 2000 and 2001. Because no owls were banded, it was not possible to track individuals through time or evaluate philopatry.

Activity patterns were determined by analyzing photographs and the event data by time of day. All TM1500 event data (date, time, event number, photograph number) were uploaded to a desktop personal computer using StatPack® computer software (Goodson and Associates, Inc., Lenexa, Kansas). Each event having a corresponding photograph was also given a description of the content of the photograph. Content categories included: adult owl(s), young owl(s) young and adult owl(s) together, prey delivery or feeding, and whether the photograph contained the maximum number of young owls photographed at a burrow during a given year. These data were then imported into a Microsoft® Excel spreadsheet. Histograms were then constructed of the number of photographs containing the various contents listed above for each hour of the day. A photograph was assigned a whole hour value based on when it was taken. For example, if a photograph was taken between 0200 and 0259 it was assigned a whole hour value of 0200.

4.3 Results

Owl reproduction was monitored at 18 to 24 active burrow sites per year over a 3-year period (Table 4-1). A total of 39 unique, active sites were monitored with 23 sites occurring in the transition ecoregion, 10 in the Mojave Desert ecoregion, and 6 in the Great Basin Desert ecoregion (Figure 4-2). Eighteen of these sites were sampled during multiple years. Over all years combined, breeding was detected at 19 of the 39 sites (49 percent) sampled (13 in transition ecoregion, 3 in Mojave Desert ecoregion, 3 in Great Basin Desert ecoregion).

A total of 20 nest burrows were documented (2 nest burrows were documented at #64 during 2000 and 2001). Of the 20 nest burrows, 16 were in human-altered habitat and 4 were in natural habitat. Eleven nest burrows were in metal culverts, 3 were in washbanks, 2 in human-made dirt mounds, 2 in roadcuts, 1 in a metal pipe, and 1 in a desert tortoise burrow. Breeding during 2 consecutive years occurred at 4 of the 20 nest burrows (3 in transition ecoregion, 1 in Great Basin Desert ecoregion), and at 1 of the 20 nest burrows (#64, transition ecoregion) breeding occurred during all 3 years.

A total of 26 breeding pairs and 122 young were detected over the 3-year period. Table 4-1 contains the number of sites sampled, breeding pairs, and young by year and ecoregion. The average number of young per breeding pair by year and ecoregion are shown in Table 4-2.

Table 4-1. Number of sites sampled, owl breeding pairs, and young detected using the TrailMaster® camera system by ecoregion from 1999-2001 on the Nevada Test Site.

	1999			2000			2001		
Ecoregion	Sites Sampled	Breeding Pairs	Young Owls	Sites Sampled	Breeding Pairs	Young Owls	Sites Sampled	Breeding Pairs	Young Owls
Great Basin Desert	3	3	10	4	1	8	1	0	0
Mojave Desert	3	0	0	7	1	3	4	2	6
Transition	12	4	14	13	6	32	18	9	49
Total	18	7	24	24	8	43	23	11	55

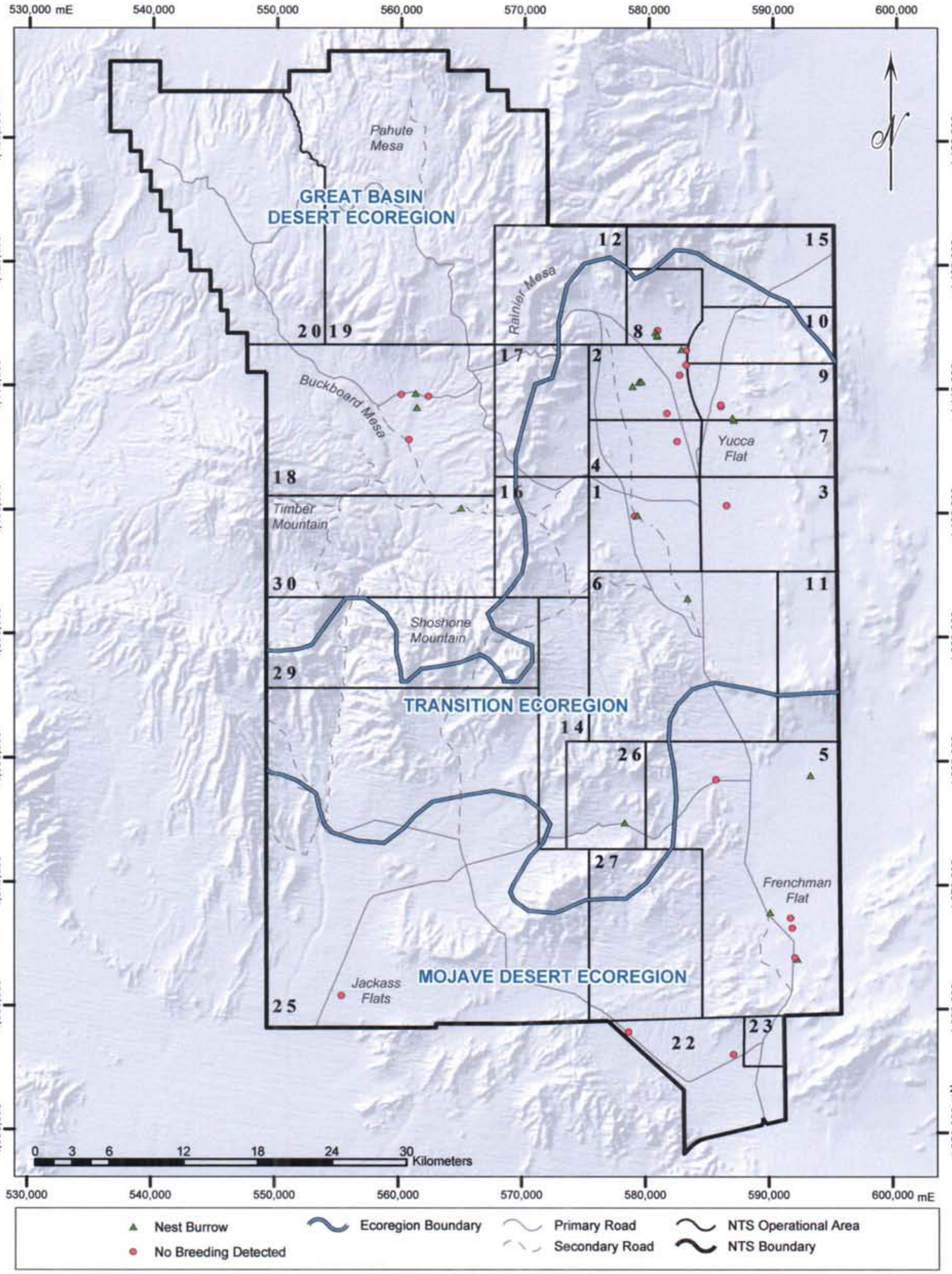

Figure 4-2. Owl burrow sites monitored with the TrailMaster® camera system, including nest burrows where breeding was detected.

Table 4-2. Average number of young per breeding pair by year and ecoregion on the Nevada Test Site (1999-2001).

Ecoregion	1999				2000				2001				1999-2001			
	Young/Pair	n	range	s.d.	Young/Pair	n	range	s.d.	Young/Pair	n	range	s.d.	Young/Pair	n	range	s.d.
Great Basin Desert	3.3	3	1-6	2.5	8.0	1	8	0.0	0.0	0	0.0	0.0	4.5	4	1-8	3.1
Mojave Desert	0.0	0.0	0.0	0.0	3.0	1	3	0.0	3.0	2	3	0.0	3.0	3	3	0.0
Transition	3.5	4	3-5	1.0	5.3	6	4-7	1.0	5.4	9	1-8	2.1	5.0	19	1-8	1.8
NTS Total	3.4	7	1-6	1.6	5.6	8	3-8	1.6	5.0	11	1-8	2.1	4.7	26	1-8	2.0

The earliest date that young were detected during each year was June 26, 1999; May 18, 2000; and May 31, 2001. The vast majority of young were detected during the months of June and July (Appendix E).

Results from the photographs reveal that the maximum number of young owls per nest burrow were most frequently detected between 0500-1000 and 1800-2200 with peaks at 0700-0800 and 1900-2000 (Figure 4-3). Prey delivery and feeding were most frequently detected in photographs between 0300-0500 and 2000-0100 (Figure 4-4). No prey delivery or feeding were detected between 0600-0800, 1100-1200, and 1300-1900 (Figure 4-4). Young owls were detected on the burrow apron during all hours of the day and night with three peaks of activity: 0500-0600, 0700-1000, and 1900-2000 (Figure 4-5). Adult owls were also detected on the burrow apron during all hours of the day and night with three peaks of activity between 0500-0600, 0800-1000, and 1500-2000 (Figure 4-6). The presence of young and adult owls on the burrow apron together was detected during all hours of the day and night with three peaks: 0500-1000, 1300-1400, and 1900-2000 (Figure 4-7). The presence of any owl on the burrow apron was also detected during all hours of the day and night with three peaks of activity: 0500-0600, 0800-1100, and 1600-2000 (Figure 4-8). Events (times when the infrared light beam was broken regardless if a photograph was taken) were recorded during all hours of the day and night with three peaks of activity: 0500-0600, 0900-1000, and 1600-2000 (Figure 4-9).

Approximately 2,828 photographs were taken during the monitoring period. Of these 2,225 (79 percent) contained pictures of owls, 406 (14 percent) contained pictures of animals other than owls, and 197 (7 percent) showed nothing. Other animals detected at burrow entrances in the photographs include badger (*Taxidea taxus*), coyote (*Canis latrans*), kit fox (*Vulpes macrotis*), bobcat (*Felis rufus*), desert cottontail rabbit (*Sylvilagus audubonii*), black-tailed jackrabbit (*Lepus californicus*), antelope ground squirrel (*Ammospermophilus leucurus*), kangaroo rat (*Dipodomys* spp.), woodrat (*Neotoma* spp.), greater roadrunner (*Geococcyx californianus*), unidentified passerines, and raven (*Corvus corax*).

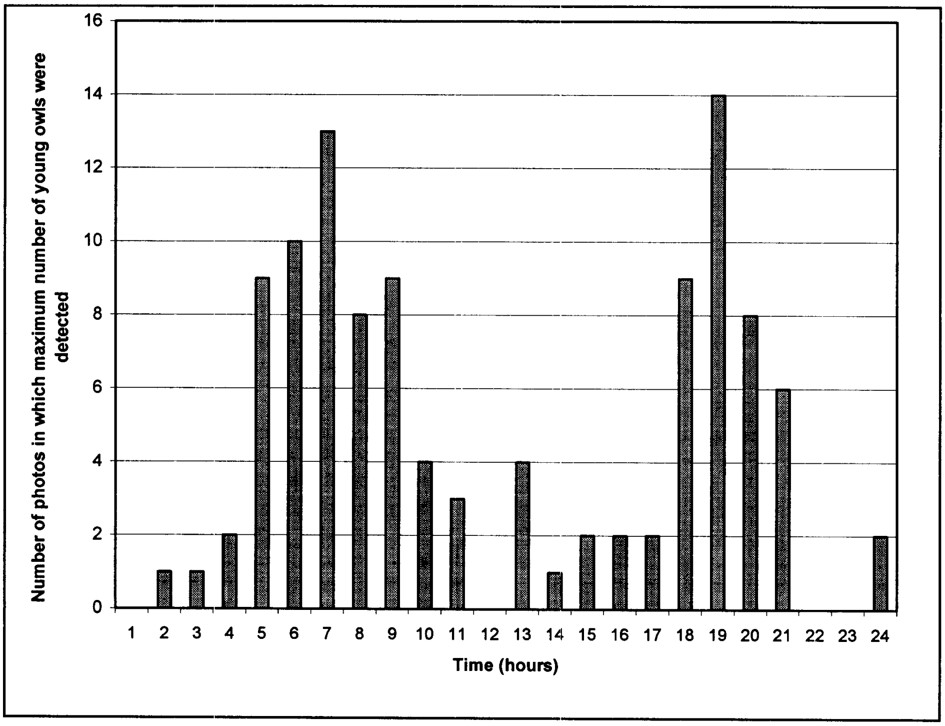

Figure 4-3. Frequency distribution of times when the maximum number of young owls per nest burrow were detected photographically (n=110).

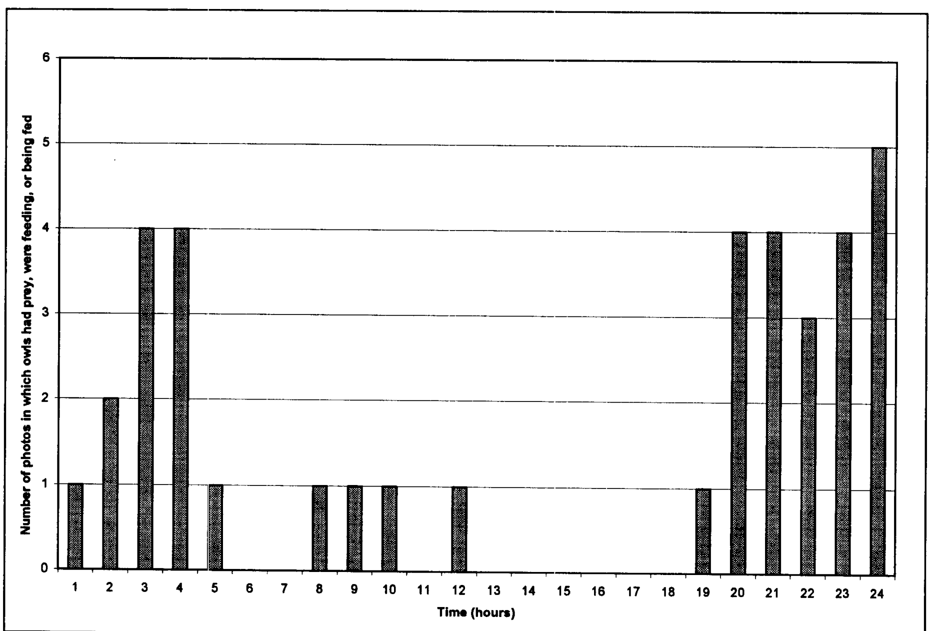

Figure 4-4. Frequency distribution of times when prey delivery or feeding was detected photographically (n=37).

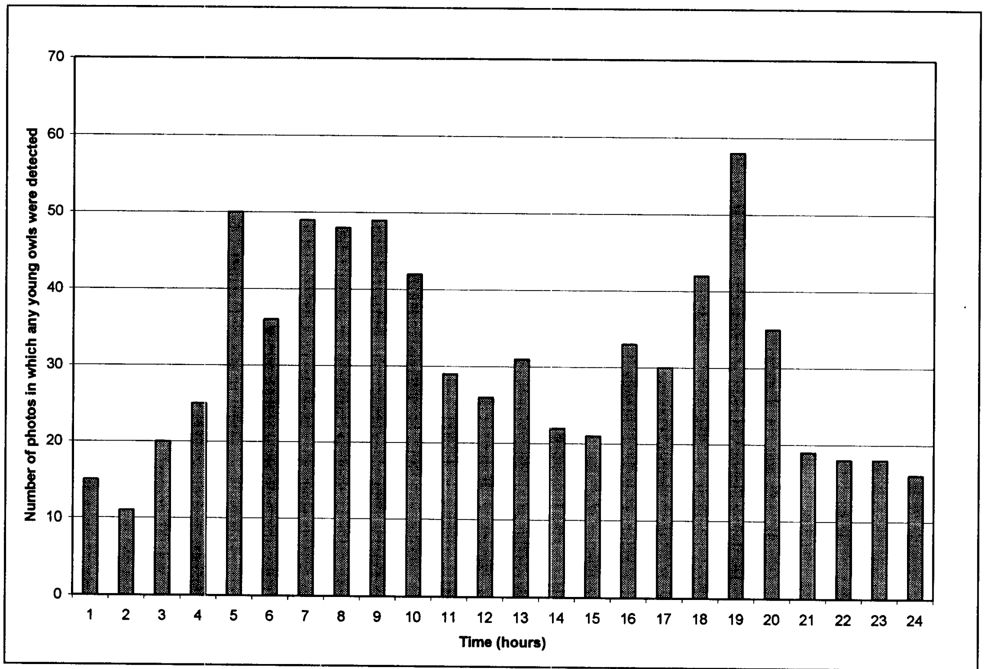

Figure 4-5. Frequency distribution of times when young owls were detected photographically (n=743).

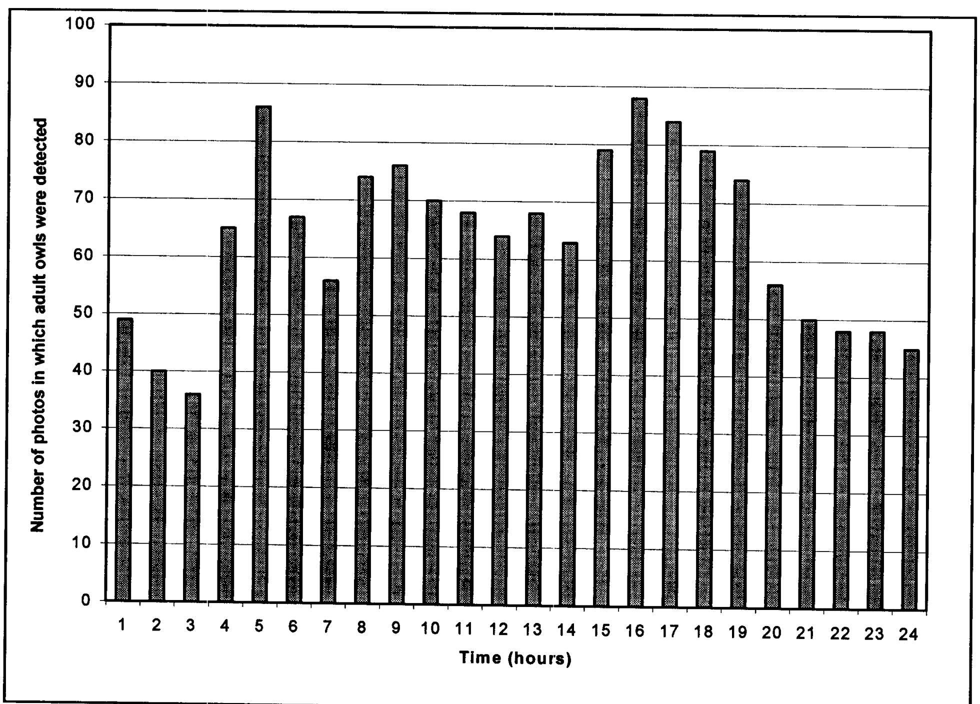

Figure 4-6. Frequency distribution of times when adult owls were detected photographically (n=1,533).

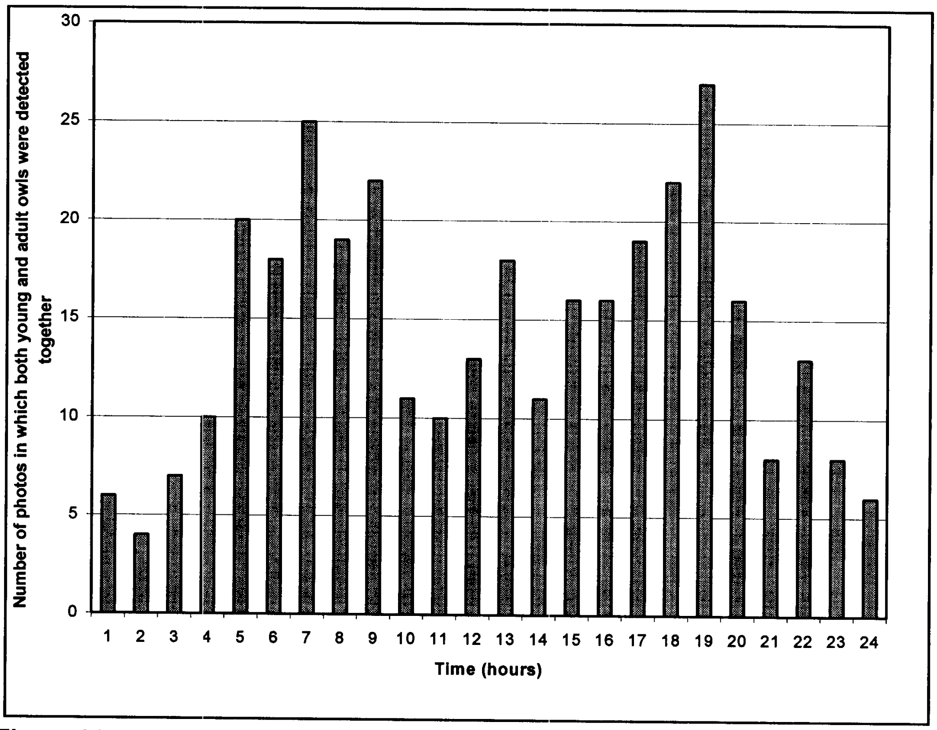

Figure 4-7. Frequency distribution of times when young and adult owls together were detected photographically (n=345).

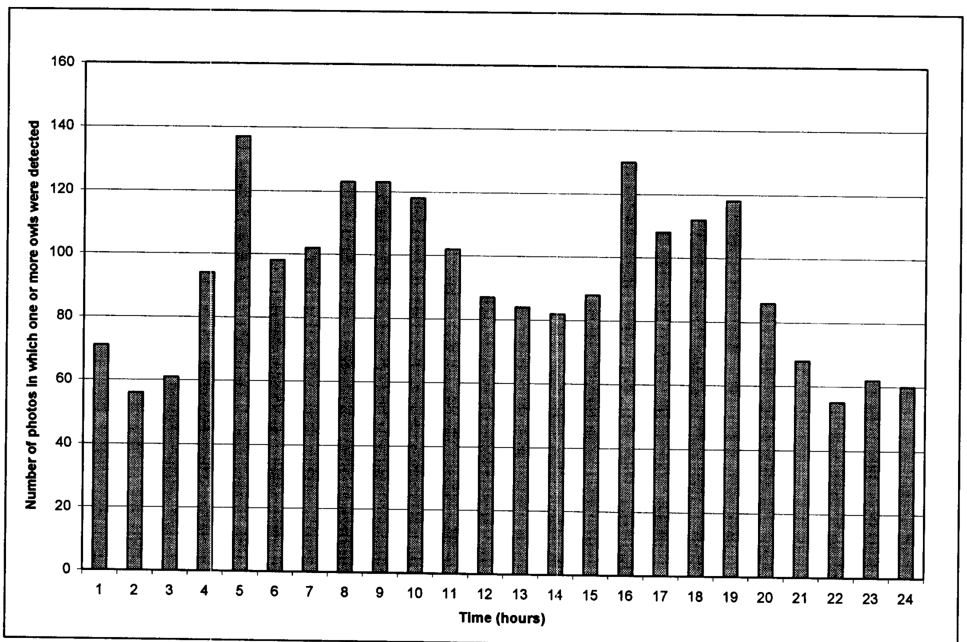

Figure 4-8. Frequency distribution of times when any owls were detected photographically (n=2,225).

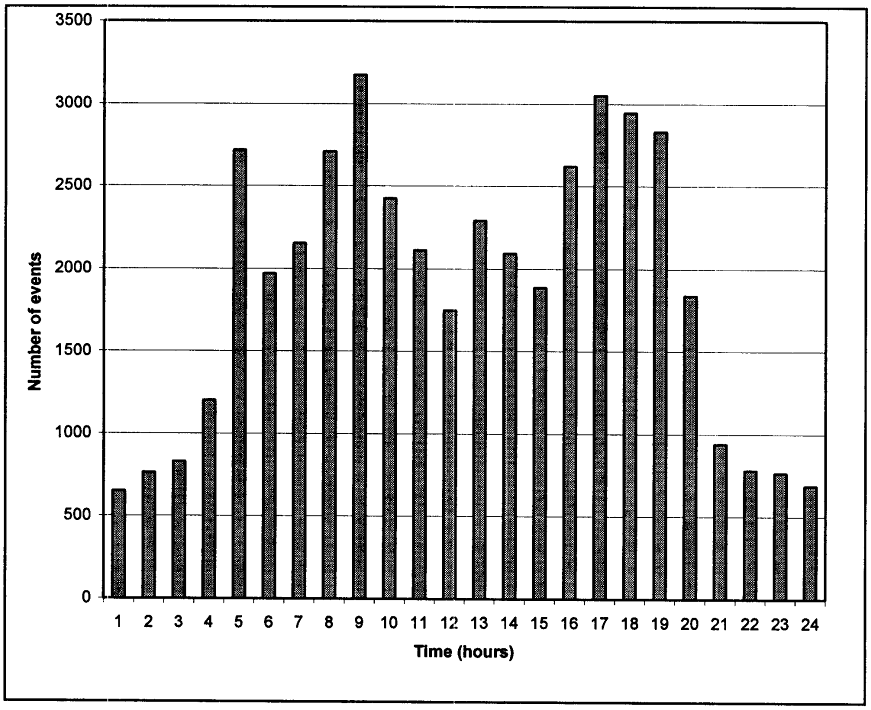

Figure 4-9. Frequency distribution of times when events were recorded by the TrailMaster® camera system (n=45,188).

4.4 Discussion

4.4.1 Nest Burrow Location and Type

The transition ecoregion had the greatest number of breeding pairs and young and the most consistent reproductive activity during the three-year monitoring period. Reproductive activity in the Mojave and Great Basin Desert ecoregions was not consistent over the three-year monitoring period. The average number of young per breeding pair was similar in the transition and Great Basin Desert ecoregions and lowest in the Mojave Desert ecoregion. The transition ecoregion, primarily Yucca Flat, provides the most suitable and productive breeding habitat for owls on the NTS. Again, this is largely due to the abundance of artificial burrows and vegetation changes created by past testing activities in this area (see 3.4.2). These artificial burrows make suitable burrows for owls and other animals.

Eighty percent of the monitored nest burrows are in human-altered habitat while only 20 percent are in natural habitat. The use of human-altered habitat is consistent with other studies that have found owls utilizing habitats created by human activity (Coulombe, 1971; Thomsen, 1971; Haug, 1993; Neel, 1999). However, the extensive use (60 percent) of culverts and pipes as nest burrows by owls on the NTS appears to be a unique situation compared to other study areas described in the literature. Radke (1987) reported that about 21 percent of the owl nest sites in his study area in Washington were culverts and irrigation pipes. Gervais et al. (2003) also found owls nesting in culverts but do not quantify these.

Forty percent of nest burrows on the NTS appeared to have been dug by other animals, including desert tortoise. Zarn (1974) also documented owl nests in tortoise burrows. Haug et al. (1993) report that nest burrows used by owls are most often dug by other animals (e.g., badgers, rodents, skunks), and that the close association owls have with burrowing mammals suggests dependence on these mammals to excavate burrows for owls to use. Thomsen (1971) reports that owls can excavate holes where burrowing mammals are absent but Haug et al. (1993) add that they rarely do so. On the NTS, our data suggest that while owls use nest burrows dug by other animals, they do not use them exclusively, and the addition of partially buried culverts and pipes has significantly increased the number of suitable burrows available to nesting owls. Thus, owls on the NTS may not be as dependent on burrowing animals as much as they are in other areas. Also, nine nest burrow entrances on the NTS were lined with horse and cow dung. This practice has been documented by other researchers and is believed to mask the owl's scent (Bent, 1938; Martin, 1973; Green, 1983; Green and Anthony, 1989; Haug et al., 1993; Belthoff and King, 1994; Belthoff et al., 1995).

The closest distance documented between nest burrows was 93 m (#64). During both 2000 and 2001, two pairs with young were observed at this site. During 2001, four pairs with young were documented at four burrow sites that were within a 400-m radius of one another (#2, #3, #4, and #8, all in the transition ecoregion, Yucca Flat). Thus, in some years at certain sites owls appear to nest in loose colonies. This corresponds with the findings of Haug et al. (1993).

4.4.2 Consecutive Year Use of Nest Burrows

The percent of nest burrows used in consecutive years on the NTS (5 of 20, 25 percent) is similar to results reported by Plumpton and Lutz (1993) in Colorado who found that 4 of 20 nest burrows (20 percent) were reused the second year. In contrast, Martin (1973) in New Mexico observed that all 15 owl pairs he studied used burrows that had been occupied in previous years. Gleason (1978) in southeastern Idaho reported that 9 of 15 burrows (60 percent) were occupied in the second year of his study, and Belthoff and King (1994) documented that 15 of 30 nest burrows (50 percent) were reused in their study in southwestern Idaho.

4.4.3 Number of Breeding Pairs and Young

Overall, the average number of young per breeding pair was 4.7, which is at the upper end of the range of values determined by other researchers in the western United States (Butts, 1971; Thomsen, 1971; Martin, 1973; Smith and Murphy, 1973a; Gleason and Johnson, 1985; Botelho and Arrowood, 1998; Lutz and Plumpton, 1999; Belthoff and King, 1994; Belthoff and Smith, 2000). Most of these studies reported the number of young fledged per breeding pair. We did not determine how many of the young detected photographically actually fledged.

The increase in the number of observed breeding pairs from 7 to 11 during the course of our monitoring was a result of finding additional burrows to sample each year and does not reflect a true increase in the number of breeding pairs on the NTS. The number of young per breeding pair was lowest during 1999, highest during 2000, and intermediate in 2001. A possible explanation for this is the amount of precipitation received during the months of October to March of 1998-1999, 1999-2000, and 2000-2001. There is a strong positive correlation (r^2=.91) between the number of young per breeding pair in the transition ecoregion and October to March precipitation (as measured from a recording station in central Yucca Flat). More years of data are needed to verify this correlation. If it holds true, it may be a useful tool to predict owl reproductive output. Nagy (1988) and Sowell and Boone (1996) determined that abundance of desert vertebrates was highly correlated with precipitation during the previous winter and spring, which they defined as October to March. Saethre (1994) also found a strong correlation between small mammal density in the spring and the amount of precipitation the previous September through March. Beatley (1969) and Munger et al. (1983) showed that successful desert rodent reproduction (based on summer densities) was dependent on the presence of winter annuals that germinated from critical precipitation received the previous fall, winter, or spring. Since rodents are a major prey item of the owl, it is logical to assume that owl reproduction is strongly influenced by rodent abundance, which is driven by critical precipitation received the previous fall, winter, or spring.

4.4.4 Timing of Reproduction

The earliest date that young were detected on the NTS was May 18, 2000. The vast majority of young were detected during the months of June and July (Appendix E). Similarly, Belthoff et al. (1995) documented that the first young owls appeared above ground on May 20, 1994, in their study area in southwestern Idaho and concluded that most young were hatched between mid-May and early-June. Rich (1986) observed young near natal burrows as early as June 10 and as late as September 17 in south central Idaho.

Based on the size and plumage of the young in the photographs, it appears that reproduction was delayed during 1999 compared with 2000 and 2001. The delayed reproduction was possibly caused by the late arrival (April) of precipitation which is necessary for stimulating plant growth and rodent reproduction (Beatley, 1969). Based on our data, it is recommended that researchers using the TrailMaster® technique in similar habitat set up cameras from mid-May through mid- to late August to document which burrows are nest burrows.

4.4.5 Use of TrailMaster® Camera System

The TrailMaster® camera system worked well to quantify the number of owl breeding pairs and young at known owl burrows. It is difficult to know if all adult and young owls occupying each site were detected photographically because the actual number of owls was not known. However, after three years of fairly intensive monitoring and numerous observations, the data suggest that most, if not all, owls that occupied photographed burrows were detected using the TrailMaster® camera system. This system could be used to compare the number of owl breeding pairs over time. The number of breeding pairs on the NTS each year is too low to statistically analyze population trends; however, it is still useful to management to monitor owl breeding on the NTS. This remote camera system is a cost-effective way of quantifying owl breeding and documenting the efficacy of human-made culvert and pipe burrows as nest burrows.

The TM1500 camera system worked well, even in the severe desert climate of south-central Nevada. A few problems were encountered while using this system. The most common problem was owls and other birds perching on the camera shelter and tipping the camera so it was not focused on the burrow entrance. This problem was fixed by using two pieces of duct tape to attach the camera shelter to the fence post. Another problem was rodents or other animals chewing through the cable that connected the camera to the receiver. This was remedied by burying the cable 2.5 to 5 cm and using duct tape to cover the cable the first 30-60 cm up the fence post. It is advisable to have two or three extra cables on hand. The C-cell alkaline batteries in the transmitter and receiver lasted approximately two months and the camera battery three months with continuous use. Appendix F details the costs and time involved with this technique.

4.4.6 Activity Patterns of Young and Adult Owls

The best times to detect the maximum number of young owls at NTS nest burrows were during the morning and evening hours of 0500-1000 and 1800-2100. Most of the prey delivery and feeding occurred during the nighttime and early morning hours. Our results support those of Thomsen (1971), Zarn (1974), and Haug and Oliphant (1990) who all concluded that owls foraged at night. Based on activity data and the nocturnal habit of many of the owl's major prey items (see 5.4), it appears that owls on the NTS are primarily nocturnal hunters that find the preponderance of their larger prey items (e.g., rodents, scorpions, sun spiders) at night rather than during the day. This is not to say that they do not forage during the day because in all likelihood they do, but usually not for the larger prey items. Haug and Oliphant (1990) observed owls foraging for insects during the day but never observed owls foraging for or carrying small mammals during the day. Marti (1974) observed owls capturing only insects during daylight hours and suggests that most vertebrates must have been captured when light levels were low.

Young and adult owls were detected at the burrow entrance at all times throughout the day and night. However, they exhibited different activity patterns with adult owls being detected more frequently at the burrow apron during afternoon/early evening than young owls. Coulombe (1971) reported that young owls are frequently outside during the morning and afternoon but rarely during midday. Young and adult owls together were detected most frequently during the morning hours, a one-hour period in early afternoon, and a one-hour period around dusk. Results from the photographs (n=2,225) and the event data (n=45,188) show almost identical patterns in times when owls, regardless of age, were detected at the burrow apron, entering into a burrow, or exiting from a burrow. Owls were active during all hours of the day and night with peaks of activity right around dawn, during the mid-morning hours, and in late afternoon and evening; thus exhibiting a trimodal activity distribution. Marti (1974) studying owls in Colorado, also determined them to be active in every hour of the day with a trimodal activity distribution. Peaks of activity in his study differed somewhat from our results and included one of about five hours centered around sunrise, one of two hours just before midday, and another five-hour period centered around sunset. In Minnesota, Grant (1965) concluded that activity was concentrated in early morning and late evening, with little activity during the day. Thomsen (1971) reported that between 1200 and 1600 owls were little in evidence but came out to the burrow apron in late afternoon.

Young owls were easily distinguished from adults during May, June, and early July by a lack of barring on the breast and the presence of gray, downy feathers and white wing stripe. However, late July or August as the young owls developed their adult plumage. Wedgwood (1976) and Bent (1938) experienced similar identification problems. Figure 4-10 shows the contrast between the plumage of an adult and young owl.

4.4.7 Non-nest Burrows and Predation

Only about half of the active burrow sites sampled with the Trailmaster® system contained nest burrows. At some sites, photographs documented the presence of an adult pair, but no young were ever detected. These pairs were considered nonbreeding and one to three nonbreeding pairs were detected each year (one in 1999, two in 2000, and three in 2001), all in the transition ecoregion. Also, sometimes photographs documented older juveniles later in the season at sites where photographs from previous months' sampling had not detected any young. These sites were not considered nest burrows because it was believed that the owls had relocated to these burrows later in the season, and that these burrows were not actually the initial nest burrow. At some sites, one adult owl and no young were detected in the photographs. At many active burrow sites, no owls were detected, which suggests a short-term occupancy of these burrows (e.g., owls migrating through the area or searching for a suitable burrow). No predation events were actually observed or photographed but remains of two adult owls were found near Burrow Sites #11 and #14, both during June, 1999.

Figure 4-10. One adult (A) and eight young owls at Burrow Site #76. (Note the difference in plumage between the adult [A] and young owl [B].)

5.0 FOOD HABITS

5.1 Introduction

The objective of this study was to describe owl food habits on the NTS by ecoregion and by season by collecting and analyzing regurgitated owl pellets. Several studies have investigated the food habits of the owl (Errington and Bennett, 1935; Bent, 1938; Hamilton, 1941; Bond, 1942; Longhurst, 1942; Glover, 1953; Grant, 1965; Maser and Brodie, 1966; Ross, 1970; Coulombe, 1971; Maser et al., 1971; Thomsen, 1971; Smith and Murphy, 1973b; Marti, 1974; Gleason and Craig, 1979; Tyler, 1983; Haug, 1985; MacCracken et al., 1985b; Brown et al., 1986; Barrows, 1989; Green et al., 1993; Haug et al., 1993; Plumpton and Lutz, 1993; Rosenberg and Haley, 2003; York et al., 2002). Only one of these was conducted in Nevada, near Yerrington (western portion of the state) (Bond, 1942). Also, none of these investigated food habits of owls in the Mojave Desert.

Longhurst (1942), Coulombe (1971), Thomsen (1971), Haug (1985), MacCracken et al. (1985b), Plumpton and Lutz (1993), and York et al. (2002) point out that pellet analysis does not always provide a true picture of what owls eat because different prey are consumed differently, pellets decompose at different rates depending on their composition, and age-or sex-based differences in foraging may bias pellet analysis results. Thus, some prey items may be missed or undercounted, especially soft items that are completely digested. Grant (1965) observed owls catching at least as many amphibians as mammals yet only mammalian remains were found in pellets. Even though pellet analysis has its limitations, it is still the most practical method for determining the food habits of owls. Errington (1930) suggests that pellet analysis might be the most important approach in studying owl food habits. Plumpton and Lutz (1993) suggest that prey items found at burrows in addition to pellets should be documented to give a truer picture of owl food habits.

5.2 Methods

Known owl burrows were monitored at least monthly from November 1997 to April 1998 and from November 1998 to July 2000 (see 3.2). Pellets were collected from the burrow apron, inside the first 30 cm of the burrow, and under perches near the burrow. Prey remains found at the burrow were also recorded. All pellets collected on a given date from a single burrow site constituted a sample and were placed into a plastic bag. Each sample bag was labeled with the date, location, and number of pellets collected. Pellets were stored inside a climate-controlled building until they were shipped to Oregon State University for analysis in August 2000.

Pellets were teased apart and analyzed according to methods adapted from Maser and Brodie (1966). Invertebrates were identified to Order, rodents were identified to the lowest taxon possible (Hall, 1981; Verts and Carraway, 1998; based on specimens in Oregon State University collection), and other vertebrates were identified to Class. The data were entered into a Microsoft® Access database. Percent frequency of occurrence was calculated for each taxon by ecoregion, all ecoregions combined, and by season. Seasons were defined as follows: fall, September through November; winter, December through February; spring, March through May; and summer, June through August.

Data were analyzed statistically using Minitab® software (Minitab, 1997). Binomial logistic regression was used on the raw presence/absence data to determine if significant differences ($P \leq 0.05$) occurred among ecoregions and seasons for each taxon.

5.3 Results

A total of 292 samples (1,631 pellets) from 48 burrow sites (30 from transition, 7 from Great Basin Desert, and 11 from Mojave Desert) were analyzed (Figure 5-1). The average number of pellets per sample was 5.6 (s.d=5.8; range 1 to 38). There were no statistically significant interactions between ecoregion and season.

A total of 20 taxa were identified in the pellet analyses, including 7 taxa of invertebrates and 13 taxa of vertebrates. Some of the taxon categories encompass others (e.g., western harvest mouse [*Reithrodontomys megalotis*] is in the Muridae family). However, each category was broken out to the lowest level possible as opposed to lumping the data up into the highest level. Pellet weathering was not a problem in our study because of our frequent (at least monthly) collections.

Table 5-1 contains the results of the food habits analysis by ecoregion and for all ecoregions combined. Values with different letters are significantly different from each other at ($P \leq 0.05$). The percent frequency of samples containing any invertebrate fragment within and across all ecoregions was substantially higher than samples containing any vertebrate fragment. Across the NTS as a whole crickets and grasshoppers (Orthoptera), beetles (Coleoptera), sun spiders (Solpugida), all rodents combined, and scorpions (Scorpiones) were the most common prey items found in the pellets, occurring in more than half of the samples. Kangaroo rats (*Dipodomys* spp.) were the most common rodent found in the pellets.

Based on results from the regression analysis, the frequency of occurrence of scorpions, true bugs (Hemiptera), reptiles (Reptilia), white-footed mice (*Peromyscus* spp.), other rodents, and western harvest mice was highest in pellets collected from burrow sites in the Great Basin Desert ecoregion. Frequency of occurrence of Perognathinae and kangaroo rat remains were highest in pellets collected from the Mojave Desert and transition ecoregions, respectively. Frequency of occurrence of sun spiders was significantly higher in pellets from the Great Basin Desert ecoregion than in pellets from the transition ecoregion. No significant differences among ecoregions were found for frequency of occurrence of samples containing fragments of any invertebrate or of any vertebrate. The percent frequency of samples containing any invertebrate was high in all three ecoregions. The most diverse diet (based on number of taxa) was detected in the transition ecoregion with all taxa represented, and the least diverse diet was detected in the Mojave Desert ecoregion. True bugs, centipedes (Chilopoda), western harvest mice, dark kangaroo mice (*Microdipodops megacephalus*), sagebrush voles (*Lagurus curtatus*), and shrews (Soricidae), were noticeably absent in pellets from the Mojave Desert ecoregion while birds (Aves), dark kangaroo mice, and sagebrush voles were noticeably absent in pellets from the Great Basin Desert ecoregion.

Table 5-2 contains the percent frequency of prey items in pellets by season across the NTS. Based on results from the regression analysis, the most common invertebrate orders found in owl pellets (i.e., crickets and grasshoppers, beetles, sun spiders, and scorpions) varied

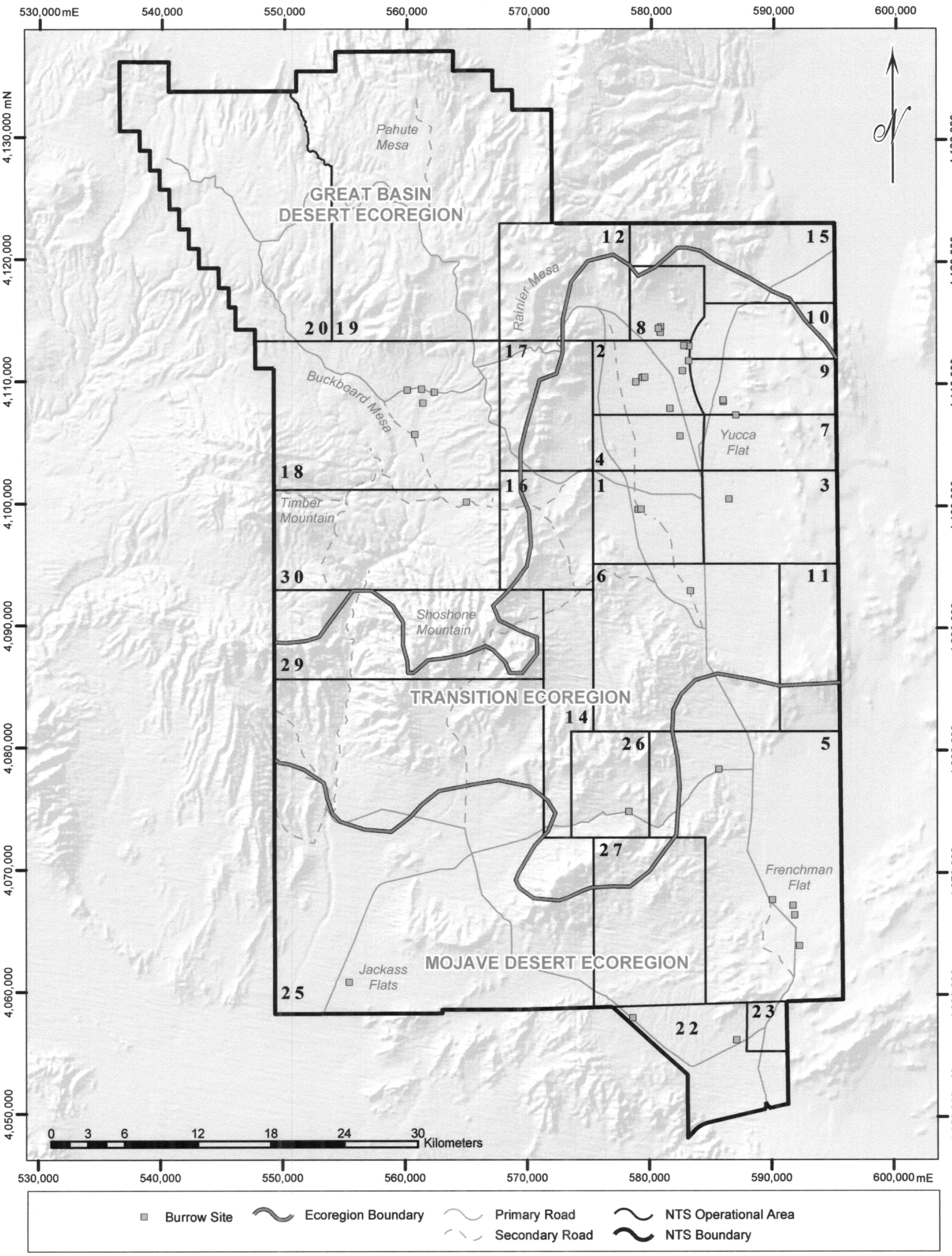

Figure 5-1. Owl burrow sites where pellets were collected for food habits analysis.

Table 5-1. Percent frequency of prey item remains in owl pellets on the Nevada Test Site by ecoregion and all ecoregions combined. Values with different letters are significantly different from each other at P≤0.05.

Taxon	Great Basin	Mojave	Transition	TOTAL
	n=58 (339)	n=43 (162)	n=191 (1,130)	n=292 (1,631)
Invertebrates				
Orthoptera	79.3a	95.3a	85.9a	86.0
Coleoptera	86.2a	72.1a	82.7a	81.8
Solpugida	75.9a	76.7ab	60.7b	66.1
Scorpiones	77.6a	58.1b	46.1b	54.1
Araneae	20.7a	16.3a	25.7a	23.3
Hemiptera	29.3a	0.0b	3.7b	8.2
Chilopoda	1.7a	0.0a	0.5a	0.7
Fragment of any invertebrate	93.1a	95.3a	95.8a	95.2
Vertebrates				
Dipodomys species	24.1b	16.3b	39.8a	33.2
Perognathinae	6.9b	39.5a	16.2b	17.8
Peromyscus species	27.6a	9.3b	11.5b	14.4
Reptilia	27.6a	16.3b	7.3b	12.7
Other rodents	27.6a	2.3b	9.9b	12.3
*Reithrodontomys megalotis**	34.5a	0.0b	6.3b	11.0
Thomomys species	3.4a	11.6a	12.0a	10.3
Aves	0.0a	7.0a	5.8a	4.8
Muridae	8.6a	4.7a	2.6a	4.1
Heteromyidae	0.0a	9.3a	2.6a	3.1
*Microdipodops megacephalus**	0.0a	0.0a	4.2a	2.7
*Lagurus curtatus**	0.0a	0.0a	1.6a	1.0
Soricidae	1.7a	0.0a	0.5a	0.7
Fragment of any rodent	72.4a	62.8a	59.2a	63.7
Fragment of any vertebrate	77.6a	69.8a	62.3a	66.4
( )=number of pellets; *=Monotypic genus on the Nevada Test Site				

significantly in their frequency of occurrence across seasons. Among vertebrates, kangaroo rats and Perognathinae varied significantly in frequency of occurrence in owl pellets across seasons. Remains of reptiles, pocket gophers (*Thomomys*), sagebrush voles, and shrews were not detected in pellets collected during fall or winter but were detected in pellets collected during spring and summer. Frequency of occurrence of pellets containing any rodent fragment was lowest in the fall and lower in summer than in spring. The frequency of occurrence of pellets containing any invertebrate fragment was lowest during winter, although invertebrates still occurred in more than 80 percent of the pellet samples collected during this season (Figure 5-2). In contrast, the frequency of occurrence of pellets containing any vertebrate fragment was lowest during fall (Figure 5-2).

5.4 Discussion

Generally speaking, owl food habits on the NTS are similar to results found in other regions with one exception. Sun spiders were a dominant prey item on the NTS. Only Gleason and Craig (1979) (southeastern Idaho), Green et al. (1993) (Oregon and Washington), Rosenberg and Haley (2003) (Imperial Valley, California), and York et al. (2002) (Imperial Valley, California) documented sun spiders as prey items, and none of these reported frequency values as high as in our study. Owl food habits on the NTS most closely resemble those described by Glover (1953) in Arizona. Bond (1942) analyzed 12 owl pellets that had been collected opportunistically in

Table 5-2. Percent frequency of prey item remains in owl pellets on the Nevada Test Site by season. Values with different letters are significantly different from each other at P≤0.05.

Taxon	Fall (Sep-Nov)	Winter (Dec-Feb)	Spring (Mar-May)	Summer (Jun-Aug)
	n=41 (213)	n=66 (186)	n=117 (806)	n=68 (426)
Invertebrates				
Orthoptera	95.1a	69.7b	88.0a	92.6a
Coleoptera	92.7a	74.2c	85.5ab	76.5bc
Solpugida	73.2ab	33.3c	70.1b	86.8a
Scorpiones	63.4ab	19.7c	58.1b	75a
Araneae	24.4a	15.2a	27.4a	23.5a
Hemiptera	4.9a	0.0a	12.0a	11.8a
Chilopoda	0.0a	0.0a	1.7a	0.0a
Fragment of any invertebrate	100.0a	83.3b	99.1a	97.1a
Vertebrates				
Dipodomys species	9.8c	24.2bc	48.7a	29.4b
Perognathinae	2.4c	15.2ab	27.4a	13.2bc
Peromyscus species	2.4a	21.2a	12.8a	16.2a
Reptilia	0.0a	0.0a	16.2a	26.5a
Other rodents	9.8a	6.1a	17.9a	10.3a
*Reithrodontomys megalotis**	4.9a	15.2a	12.8a	7.4a
Thomomys species	0.0a	0.0a	16.2a	16.2a
Aves	9.8a	6.1a	4.3a	1.5a
Muridae	0.0a	7.6a	4.3a	2.9a
Heteromyidae	2.4a	6.1a	0.0a	5.9a
*Microdipodops megacephalus**	0.0a	4.5a	2.6a	2.9a
*Lagurus curtatus**	0.0a	0.0a	0.9a	2.9a
Soricidae	0.0a	0.0a	0.9a	1.5a
Fragment of any rodent	26.8c	62.1ab	75.2a	61.8b
Fragment of any vertebrate	34.1b	66.7a	77.8a	67.6a

( )=number of pellets; *=Monotypic genus on the Nevada Test Site

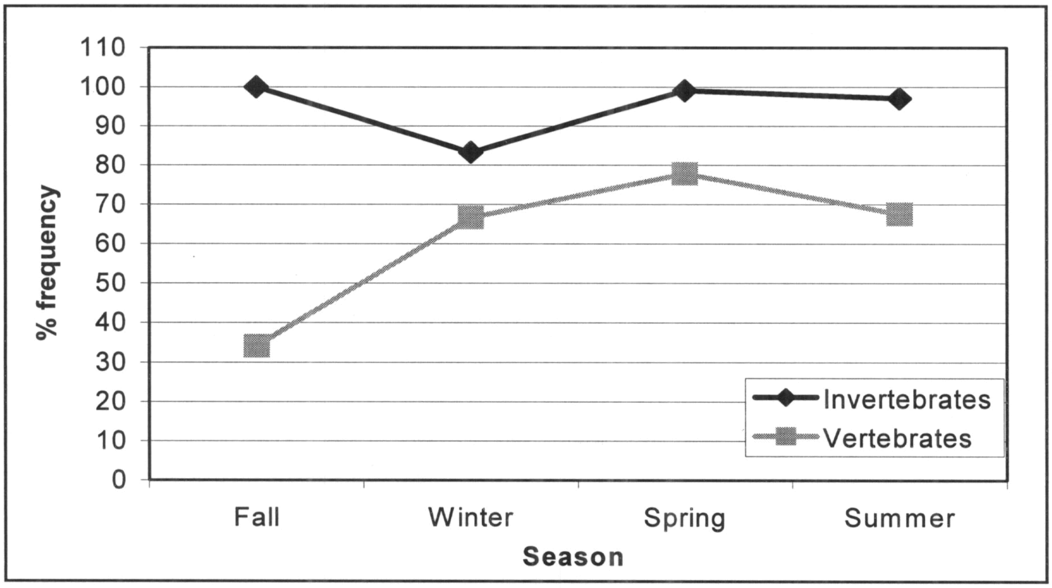

Figure 5-2. Comparison of invertebrate and vertebrate frequency of occurrence in pellets by season.

western Nevada and found spadefoot toad (*Scaphiopus* spp.) remains as the dominant prey item. No spadefoot toad remains were found in pellets on the NTS since toads are not known to occur onsite (Wills and Ostler, 2001). Our results from the Mojave Desert are similar to what Barrows (1989) found in the Colorado Desert as far as major prey items detected in the pellets; however, the proportions of major prey items detected are quite different.

There appears to be ecoregional differences in food habits. The data suggest that owls in the Great Basin Desert ecoregion do not rely on one main group of vertebrate prey items like their counterparts in other ecoregions (e.g., Perognathinae in the Mojave Desert and kangaroo rats in the transition ecoregion). This pattern may reflect prey availability within the different ecoregions. Small mammal data collected during the late 1970s at a site in the Great Basin Desert ecoregion near Buckboard Mesa (within 10 km of several burrow sites where we collected pellets) indicated that the number of rodent species was higher than at sites in the Mojave Desert and transition ecoregions (Bradley and Moor, 1978; Moor and Bradley, 1985). Pellet analysis showed that vertebrate prey items found in pellets in the Great Basin Desert ecoregion were similar to the species captured in this ecoregion with one exception. Western harvest mice were not captured in these studies but occurred in 35 percent of the pellet samples. Also, Saethre (1995) showed that over an eight-year period (1987-1994) Merriam's kangaroo rat (*Dipodomys merriami*) was the most prevalent rodent on disturbed areas (primarily in the transition ecoregion) of the NTS. These disturbed areas are the same areas where many of the burrow sites are located and where most of the pellets were collected. This may explain why kangaroo rats were the dominant prey item in the transition ecoregion.

Invertebrates are a substantial part of the diet in all ecoregions across all seasons, but their frequency of occurrence is lowest in pellets collected during winter (Table 5-2; Figure 5-2). This pattern follows the pattern of relative availability of most invertebrates which is generally lowest during the colder winter months. Based on invertebrate studies conducted by Brigham Young University in the early 1960s, some patterns emerge when comparing their data with our pellet analysis data. Tanner and Packham (1965) found that Tenebrionid beetles, nocturnal plant feeders, had two population peaks, one in May and one in September with moderate numbers during the summer and low numbers October through February. Likewise, the pellet analysis data show a pattern of high occurrence of beetles (unknown families) in pellets collected during spring and fall that may correspond with the population peaks of Tenebrionid beetles. Also, Barnum (1964) determined that crickets and grasshoppers were found mostly during March through November. This corresponds with our finding that the frequency of occurrence of crickets and grasshoppers in pellets was significantly lower during winter than in any other season. Gertsch and Allred (1965) studied scorpions on the NTS and found that they were nocturnal and most active between June and September with the highest population peaks in July and August. Our data show a pattern of higher occurrence of scorpions in pellets collected during the summer, intermediate in the fall and spring, and lowest in winter. Muma (1963) studied sun spiders on the NTS and determined that they were nocturnal, cursorial predators, and that most adults were collected during spring and summer. Like the scorpions, our food habits data show that sun spiders have a pattern of higher occurrence in pellets collected during the summer, intermediate in the fall and spring, and lowest in winter.

Vertebrates occur less frequently in owl pellets than invertebrates but are still a significant part of the diet, especially given their larger body size. Vertebrate prey items occur least frequently in pellets collected during the fall and of equal frequency in pellets collected during winter, spring, and summer (Table 5-2, Figure 5-2). Reasons for this pattern may include prey availability, different seasonal energetic demands of owls, or most likely a combination of both.

Declines in the percentage of vertebrate prey and increases in invertebrate prey were not found during the breeding season in our study, unlike other studies (Errington and Bennett, 1935 [Iowa]; Green, 1983 [Oregon]; Haug, 1985 [Saskatchewan]; MacCracken et al., 1985b [South Dakota]). Our results more closely resembled the results of Butts (1973) and Tyler (1983) in Oklahoma who showed that invertebrates were found in lowest occurrence during winter and vertebrates in highest occurrence during winter and spring.

Our data, like most other studies, suggest that both invertebrate and vertebrate prey are important components of the owl's diet. Furthermore, our results support the general premise of other researchers that owls are opportunistic feeders and have a generalist feeding strategy, rather than focusing on only one or a few food types.

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6.0 DISTURBANCE EFFECTS

6.1 Introduction

Only a couple of studies have been conducted on human disturbance effects on the western burrowing owl (Plumpton and Lutz, 1993; Botelho and Arrowood, 1996) and a few additional studies on the Florida burrowing owl (*Athene cunicularia floridana*) (Wesemann and Rowe, 1987; Mealey, 1997; Millsap and Bear, 2000). Plumpton and Lutz (1993) measured time budgets of owls (i.e., how much time owls engaged in predefined behaviors) in response to vehicular traffic, and found no significant effects of vehicular traffic on productivity. Millsap and Bear (2000) found that high disturbance levels (>60 percent occupancy in subdivisions) due to homebuilding caused nest failures and decreased productivity of the Florida burrowing owl in Florida. They reported that Florida burrowing owls fledged more young if buffer zones greater than 10 m were established around active nests. Buffer zones are areas of a certain distance around active burrows in which human activity is limited or denied so as to avoid disturbing owls at their burrows. Buffer zones are normally of two types: spatial (i.e., defined area around burrow is protected) and temporal (i.e., only apply at certain times of the year). Recommended buffer zones for the western burrowing owl include prohibiting Carbofuran insecticide use within 250 m of occupied nest burrows in Canada (Haug, 1993), pesticide-and herbicide-free zones of 600-m radius around burrows in Idaho, and prohibiting human activities within 200 m of nest burrows in Oregon and Washington (Klute et al., 2003). For other species of raptors, recommended buffer zones have been summarized by Richardson and Miller (1997) and Holmes et al. (1993).

Our primary objectives were to determine the size of buffer zones that would protect owls and their burrows and determine their tolerance to different disturbance types (e.g., traffic, human activity near burrow). To accomplish these goals we examined: (1) the flushing distance of owls in response to biologists approaching the burrow site on foot and in a vehicle, (2) the relationship between the number of young per nest and vehicle traffic rates at various distances from nest burrows, and (3) the distance from burrows to existing disturbances.

6.2 Methods

We measured the flushing distance of owls in response to biologists approaching a burrow on foot (walking) and in a vehicle during reproductive and monthly burrow monitoring from 1999-2001. The flushing distance is the distance between the observer and the owl at the time the owl flies away from or moves into the burrow in response to the human disturbance. In each instance, the biologist drove up to a site, stopped the vehicle, exited the vehicle, and approached the burrow on foot. Sometimes the owl flushed before the biologist got out of the vehicle. The flushing response to a vehicle was defined as a response either to a moving or stopped vehicle. The flushing response to walking began as a person exited the vehicle and walked towards the burrow. The distance at which the biologist began walking towards the burrow generally varied from about 10-70 m. The date, time, temperature (°C) at 3-6 inches above the burrow apron and at waist height, cloud cover (percent), wind speed (km per hour) and direction, and flushing distance by pacing (converted to meters) were recorded. We calculated mean flushing distance in response to walking and vehicle disturbance from all observations over all years and burrow sites. Many of the burrow sites monitored were active nest burrows. A distance was also calculated at which 90 percent of flushing responses would have been avoided

Traffic counters were set up during the breeding season (April through August/September) of 2000 and 2001 along various roads near owl nests to measure traffic rates. Traffic counters were powered by a 6-volt battery and consisted of a counter and a length of hollow rubber hose long enough to lie across the whole road. One end of the hose was connected to the counter and the other end was plugged so air could not escape. When the hose was run over by a vehicle, the counter recorded an event. An event consisted of two sets of wheels running over the hose (i.e., one event equaled one double-axle vehicle). We selected sites that had a wide range of traffic (light to heavy) in each ecoregion as close to active burrows as possible. We measured the distance from each traffic counter to the nest burrow and checked counters at least monthly to record data and ensure that they were still working. We recorded time of day, traffic count, and presence of owls/fresh sign during each visit. An average traffic rate of vehicles per day was calculated for each site by dividing the total number of traffic counter events by the number of days traffic counters were in operation. The maximum number of young per nest burrow (as detected by the TrailMaster® camera system) was regressed against traffic rate (counter events per day) and distance from traffic counter to each nest burrow using multiple linear regression to determine if there was any correlation between traffic rate and proximity of traffic and the number of young owls per nest. Percent burrow use rate at each burrow site (BURS) was also regressed against traffic rate and distance from counter to each burrow using multiple linear regression to determine if there was any correlation between traffic rate and BURS during the breeding season.

In order to characterize the location of the different burrows in relationship to surrounding disturbances, we measured the distance (m) (by pacing or estimating from a 1:24,000 U.S. Geological Survey topographic map) between a burrow and the nearest disturbance within approximately 400 m of each burrow. Disturbances included roads (paved, gravel, dirt), buildings, high perches (power lines), low perches (road signs), drill pads, craters, borrow pits, dirt mounds, other miscellaneous disturbances, or any ongoing construction or nearby activity. Disturbances were alterations of the original habitat near burrow sites that could potentially affect owls either negatively or positively. For example, human-made elevated perches near the nest site may have a negative effect if owl predators can use these perches to prey upon adults or young. In contrast, such human-made perches may be beneficial if the owls use them to detect predators or prey. Also, for burrow sites with multiple burrow openings, average distances to disturbances were calculated by dividing the total summed distance to a given disturbance for all burrow openings at a site by the total number of burrow openings at that site. Statistical comparisons, using simple linear regression, of BURS verses minimum average distance to various disturbances were made to determine if proximity to certain disturbances influenced BURS. Some disturbance types were not included in the analysis due to low sample size.

6.3 Results

Histograms of owl flushing distances in response to walking and vehicles are similar (Figures 6-1 and 6-2, respectively). The minimum flushing distance at which 90 percent of flushing responses would have been avoided is 57 m for walking and 55 m for vehicles. Mean

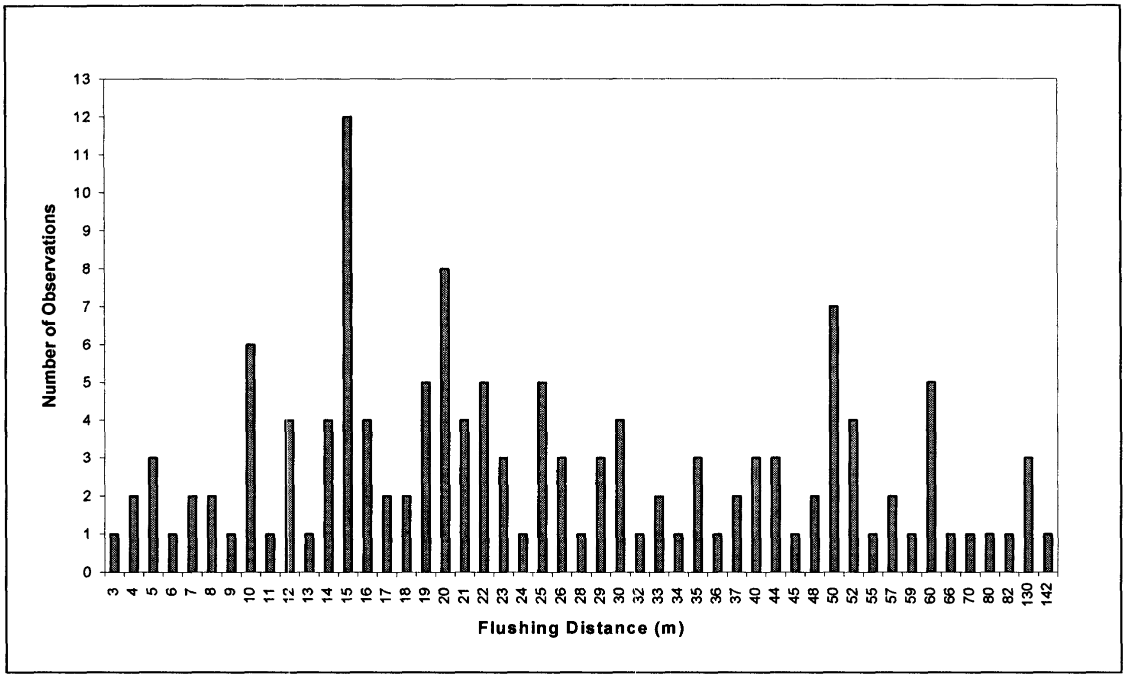

Figure 6-1. Histogram of flushing distance in response to biologists walking towards burrow sites on the Nevada Test Site (n=137).

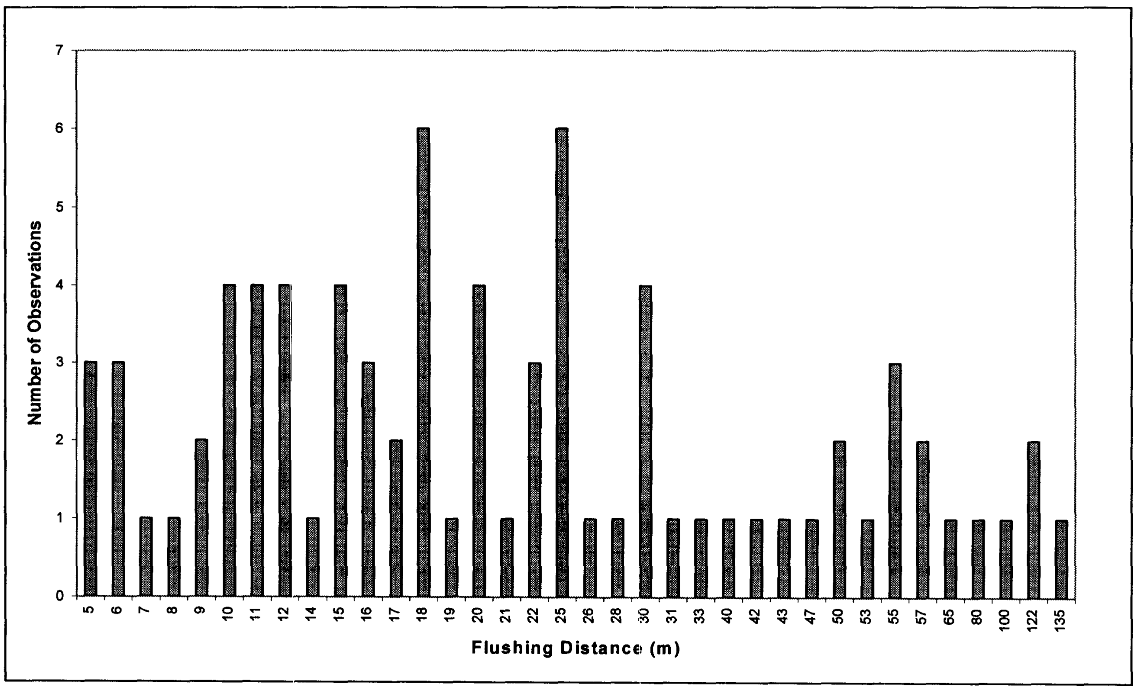

Figure 6-2. Histogram of flushing distance in response to vehicles at burrow sites on the Nevada Test Site (n=79).

Table 6-1. Average flushing distances in response to walking and driving vehicles towards burrow sites.

Owl Response	Flushing Distance (m)							
	Walking				Vehicle			
	Mean	SD	Range	n	Mean	SD	Range	n
Flush from burrow	28.3	20.4	3-142	117	31.4	29.0	5-135	62
Flush into burrow	45.0	39.1	7-130	20	18.6	11.2	5-53	17
All Responses	30.7	24.8	3-142	137	28.7	26.7	5-135	79

flushing distances are shown in Table 6-1. The average flushing distance of owls away from the burrow in response to walking and vehicles was similar, approximately 28 and 31 m, respectively. In contrast, there were differences in the average flushing distances of owls into the burrow in response to walking and vehicles, 45 and 19 m respectively. Owls flushed into burrows less often (37) than they flew away (179). The mean flushing distance for all responses combined was similar for walking and vehicle disturbances (31 and 29 m, respectively). The range of owl flushing distances observed was large (3-142 m). The complete data set of owl sightings, types of flush responses, and climatic data are given in Appendix G.

We monitored traffic rates at 16 and 18 owl burrow sites on the NTS during 2000 and 2001, respectively (Figure 6-3). At these locations, 7 and 10 nest burrows produced young during 2000 and 2001, respectively (Tables 6-2, 6-3). The rate of vehicular disturbance (vehicles per day) measured during these years at all burrow sites varied from a low of 0.2 to a high of 617.4 during 2000 and 2001 (Appendix H).

The range of traffic varied greatly at sites with young. One site produced three young at a burrow experiencing one of the highest traffic rates 65 m away from the nest burrow (Table 6-3). There was no significant correlation ($r^2 = 0.12$) between number of young detected at nest burrows and traffic rate and distance to the nest burrow from the road. Likewise, no significant correlation ($r^2 = 0.07$) was evident between BURS and traffic rate and distance to the nest burrow from the road. One site on Frenchman Flat (#32) had high traffic in two consecutive years but had breeding in only one of the two years studied (Appendix H). Complete data sets on traffic studies and owl breeding and BURS at burrow sites near roads is shown in Appendix H.

There were no significant correlations between distance to disturbances recorded near owl burrows (e.g., mean distance to roads, buildings, elevated perches) and BURS across sites (Appendix I). Complete data sets of distances to all nearest disturbances at each burrow site are given in Appendix J.

6.4 Discussion

Based on the flushing distance data, we recommend a buffer zone of 60 m for walking and vehicular traffic around any active owl burrow. If a buffer distance of ≥60 m is maintained

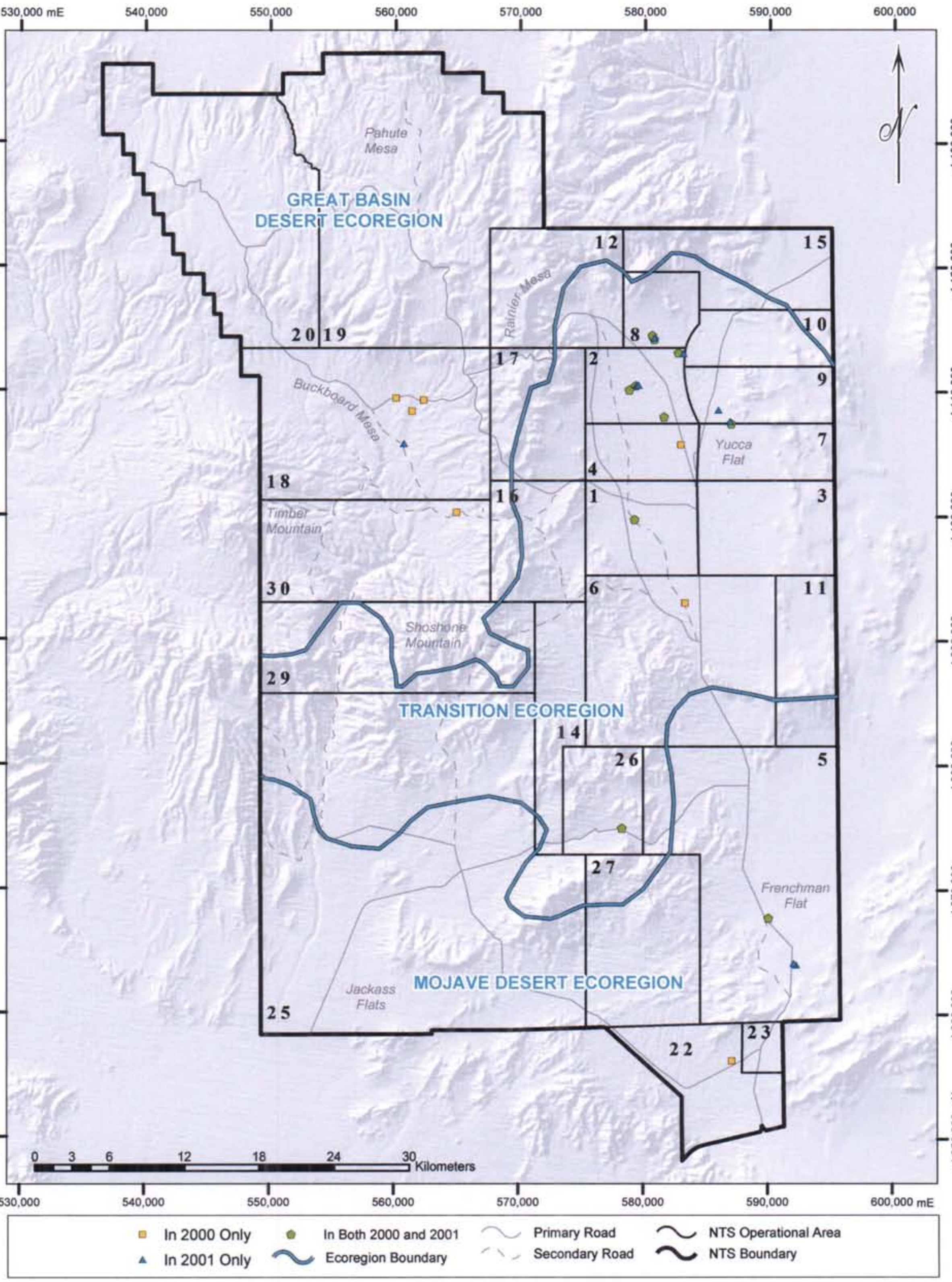

Figure 6-3. Owl burrow sites monitored with traffic counters during 2000 and 2001.

Table 6-2. Vehicle traffic rates, distance to nest burrow, and number of young detected at burrow sites on the Nevada Test Site during 2000 and 2001 .

Burrow Site	Vehicles/ Day	Distance to Nest (m) from Road	Young Detected
2000			
Area 26, Cane Spring Road, Wash (#30)	40.2	165	6
Area 2, 2-07 Road, 2L-18 Pad (#67)	10.2	45	7
Area 18, Airport Road #2 (#38)	5.7	14	8
Area 8, 8D Road, Pad (Nest E) (#64)	0.4	196	7
Area 8, 8D Road, Pad (Nest B) (#64)	0.4	269	4
Area 9, Powerline Road, Pad (#15)	0.4	145	5
Area 1, Orange Road, O-30 #2, Wash (#43)	0.3	48	5
2001			
Area 5, Mercury Highway, M-27	487.8	65	3
Area 2, 2-04 Road, East (#4)	1.9	78	4
Area 2, 2-04 Road, West (#3)	1.8	11	4
Area 2, 2-04 and 2L Roads Intersection (#2)	1.2	10	1
Area 9, Powerline Road, Pad (#15)	0.9	172	6
Area 9, 9-01 Road, 9G-11 (#73)	0.9	75	7
Area 8, 8D Road, Pad (Nest E) (#64)	0.4	196	6
Area 8, 8D Road, Pad (Nest B) (#64)	0.4	269	6
Area 8, 8D Road, 8D-2 #2 (#76)	0.4	120	8
Area 2, 2L Road, 2L-5 (#8)	0.2	11	7

between humans walking and vehicles driving near burrows, our data indicate that over 90 percent of owl flushing responses will be prevented. Researchers setting buffer zones around nests of other raptor species have also used distances that would prevent 90 percent of flushing responses from occurring (White and Thurow, 1985; Holmes et al., 1993). The buffer distance of >10 m recommended by Millsap and Bear (2000) would only have avoided 16 percent of flushing responses based on our findings. The Florida burrowing owls they studied were probably more habituated to humans than owls in our study and thus tolerated human presence closer to their burrows.

Traffic rates measured during this study were low in most cases. There was no statistically significant effect of traffic on owl productivity. It appears that owls are very tolerant of traffic even up to levels approaching nearly 500 vehicles a day if their burrows are far enough away from the road (Table 6.3). Our results are consistent with those of Plumpton and Lutz (1993) who found no impact of traffic on owl productivity near owl nesting colonies in Colorado, where daytime traffic levels varied from 0-64 vehicles per hour. In addition, we recorded only three active projects on the NTS during this study in close enough proximity to any burrow site that could have potentially affected owls. Only one of these projects occurred during the breeding season.

We found no significant correlations between BURS and any type of disturbance within 400 m of the burrow sites (all $r^2 < 0.20$ for eight types of disturbances analyzed separately, Appendix I). Other factors such as prey availability, predation pressure, and microhabitat preferences (e.g., percent bare ground, percent vegetative cover, and vegetation height around burrows) influence burrow use rates.

7.0 WINTER BURROW TEMPERATURE PROFILES

7.1 Introduction

Owls spend much of their time underground in burrows. Few studies have been conducted to describe the microclimate of these burrows. Coulombe (1971) in southern California took limited measurements (one to seven measurements a day on five different days between June 23, 1965 and May 19, 1967) of ambient air temperature, temperature at the burrow entrance, temperature at 30 cm inside burrows, and relative humidity. Absolute humidity was also calculated. His results showed that temperatures were not significantly different among ambient air, the burrow entrance, or 30 cm into the burrows, but the amount of water vapor in the air was significantly higher inside the burrows compared to ambient air. He concluded that, "Burrows were found to provide a buffered ecoclimate for these owls throughout the year." Limited observations by Butts (1976) and studies by Wilcomb (1954) in Oklahoma indicate that temperatures in prairie dog burrows (commonly used by burrowing owls) seldom fall below 4.4 °C 150 cm inside the burrow and under the shallow frost line.

The objectives of this study were to (1) characterize the winter temperature profiles inside burrows of different types and depths and (2) determine the temperature difference between air temperatures inside and outside burrows.

7.2 Methods

Temperature data were collected using reusable temperature data loggers (Hobo-Temp, Onset Computer Corporation, Pocasset, Massachusetts). The maximum error and resolution reported for the data logger is 0.7 °C to 1.0 °C and 0.4 °C to 0.8 °C, respectively between –20 °C and +40 °C. Mueller and Rakestraw (1995) studying desert tortoises (*Gopherus agassizii*) evaluated these instruments and concluded that they were reliable, easy to use, and valuable tools for field studies. Measurements on humidity were not taken.

In order to minimize disturbance to nesting owls, temperature data were only collected during the winter and early spring months. Data loggers were emplaced in six burrows from December 10, 1997, to March 25, 1998, and in six burrows (four of the same burrows sampled the previous year) from December 16, 1998, to March 30, 1999. Data loggers were programmed to take a temperature reading every 90 minutes. Data loggers were emplaced by tying fly-line backing to the data logger, threading the backing through schedule 40 PVC pipe, and inserting the data loggers into the burrow as far in as the pipe could be inserted but not to exceed 6.1 m, then pulling the pipe out of the burrow and attaching the end of the fly-line backing to a heavy object near the burrow entrance. Data loggers were pulled from the burrow by retrieving the string.

Burrows were subjectively selected based on the probability of occupancy by owls during the winter and to provide a range of depths and burrow types for temperature comparisons. At each burrow, one data logger was emplaced inside the burrow and one was mounted to a fabricated structure and set near the burrow entrance to record ambient air temperature. The fabricated structure was insulated with styrofoam, and the data logger was attached to the styrofoam about

15 cm above the ground in the shade of the structure. Depth of emplacement was measured directly by digging down to the top of the culvert and measuring the distance between the soil surface and the top of the culvert and adding the height of the culvert or calculated by measuring the angle of the slope (A) into the burrow with a clinometer and the length of the slope (c). Depth (a) was then calculated using the formula $a=c*sine(A)$. Owl occupancy was determined by checking each burrow approximately every two weeks. On each visit, any sign (e.g., pellets, scat, feathers) on or around the burrow apron was documented and cleared away. If new sign was found on the next visit, it was assumed that the burrow was occupied by an owl.

After data loggers were retrieved, they were taken back to the office and the data was uploaded onto personal computers using HOBO® software. The data were brought into a Microsoft® Excel spreadsheet and summarized. For each study period (i.e., 1997-1998 and 1998-1999) data were summarized by entire period and by month. Descriptive statistics (mean, minimum, maximum, and standard deviation) were calculated for each data logger data set.

Temperatures were not recorded continuously through the study period at every burrow for two primary reasons. First, some of the data loggers were pulled out onto the burrow apron either by an owl or other animal. When this occurred, burrow temperature data was not adequately measured and the data was discarded. Second, a few of the data loggers did not function properly (e.g., dead battery, got too wet). For Burrow Site #14 (1997-98), the data loggers were not emplaced until January 27, 1998. The data logger for measuring ambient air temperature at Burrow Site #2 (1998-1999) was erroneously set to take a measurement every hour as opposed to every one and one-half hours to measure burrow temperature so the two data sets could not be compared. Ambient air and burrow temperature data for each burrow were averaged over the same time periods so accurate comparisons could be made between the two temperature data sets.

A total of eight burrow sites were sampled over the two study periods December to March 1997-1998 and 1998-1999. Six sites were sampled each period. Four of the sites (#2, #14, #30, and #36) were sampled during both periods. Burrow Site #36 was a natural burrow located just west of Mercury and was the only site located in the Mojave Desert ecoregion. Burrow Site #30 was located in a caliche washbank in the transition ecoregion. Burrow sites #15, #2, #14, #13, and #41 were in metal culverts located in Yucca Flat in the transition ecoregion. Burrow Site #9 was in a roadcut and was the only site sampled in the Great Basin Desert ecoregion.

7.3 Results

Figure 7-1 shows the burrow sites where data loggers were set to record temperature data. Figures 7-2 and 7-3 graphically depict the burrow temperature profiles during 1997-1998 and 1998-1999, respectively. Tables 7-1 and 7-2 contain the average ambient air and burrow temperature data in tabular form with corresponding descriptive statistics for each burrow sampled during 1997-1998 and 1998-1999, respectively. Corresponding graphs of ambient and burrow temperatures by burrow for the two study periods are found in Appendix K.

<u>December 1997--March 1998.</u> Average burrow temperature of all six sites was 8.4 °C and ranged from 6.0 °C at Burrow Site #15 to 11.7 °C at Burrow Site #36. Two of the deeper burrow

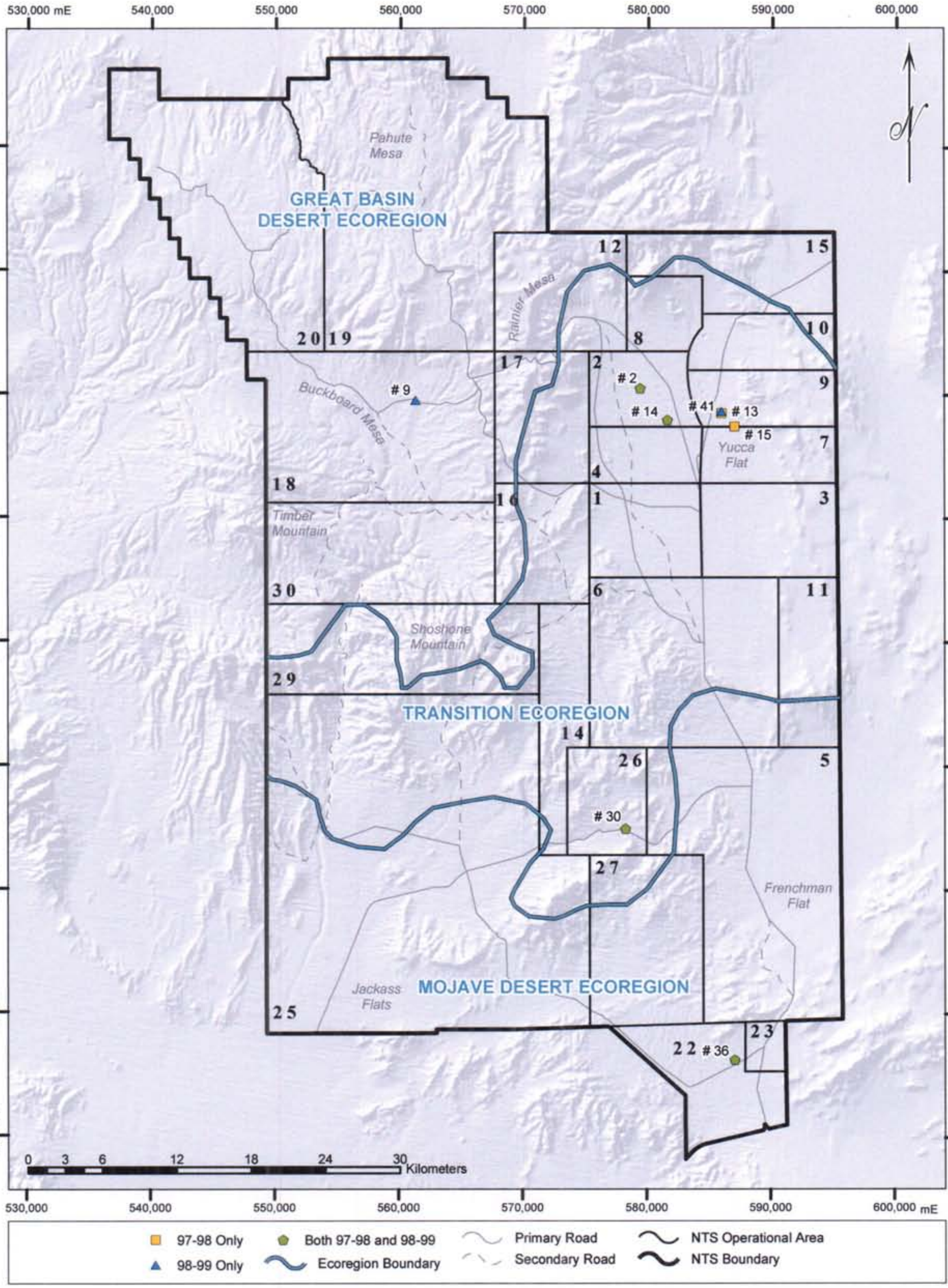

Figure 7-1. Owl burrow sites monitored with temperature data loggers.

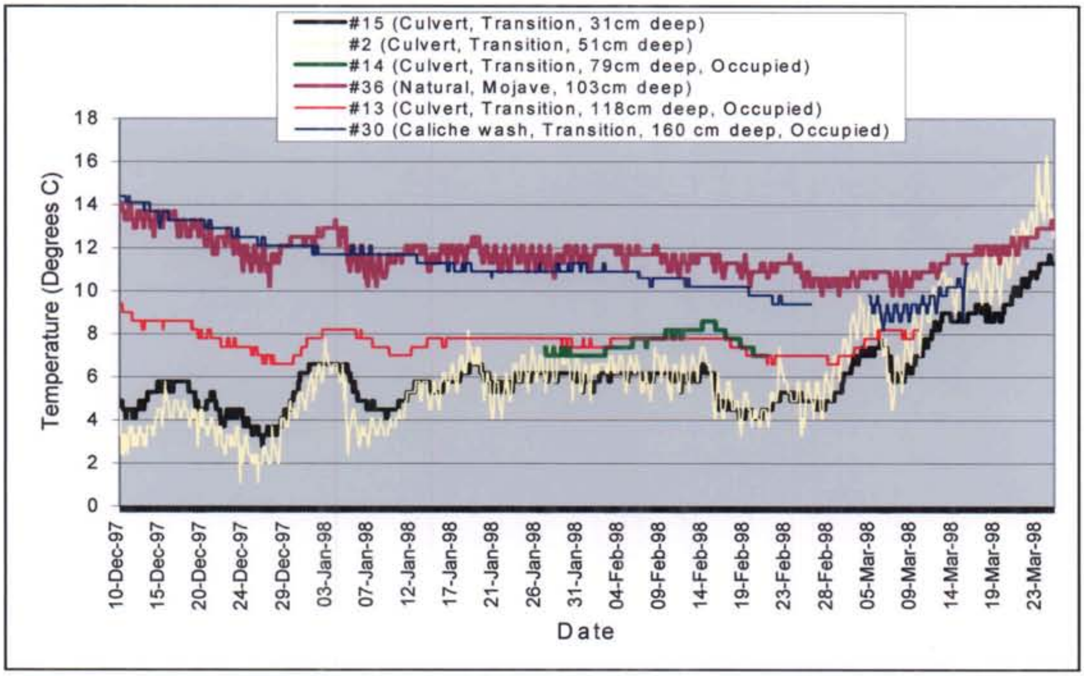

Figure 7-2. Internal burrow temperature profiles for six burrow sites monitored from December 1997 to March 1998.

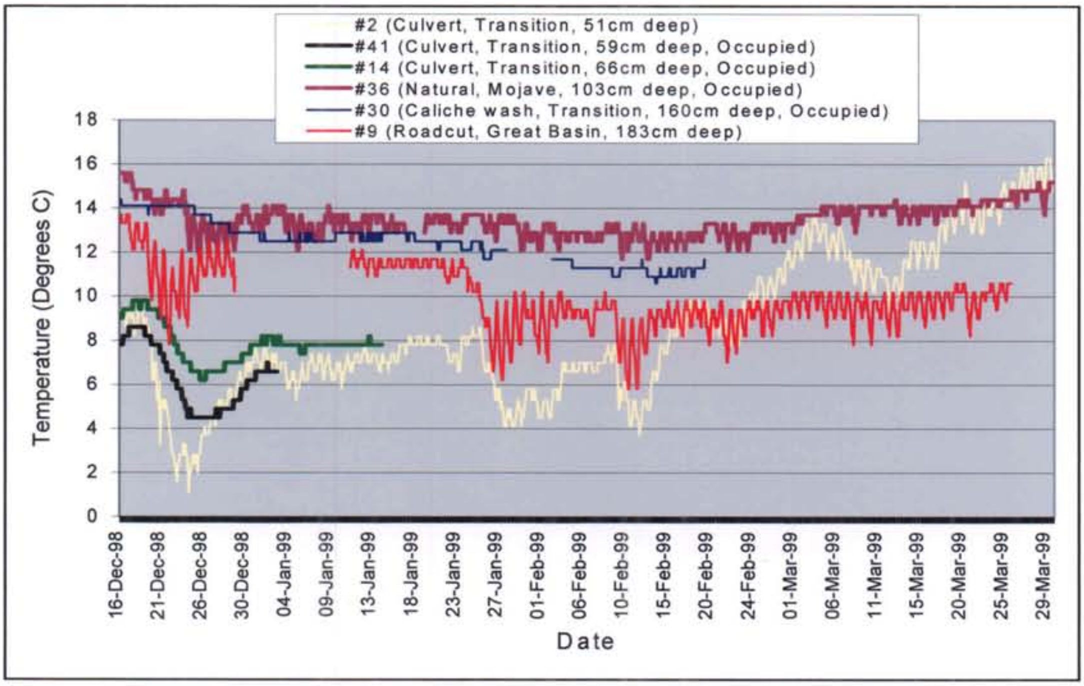

Figure 7-3. Internal burrow temperature profiles for six burrow sites monitored from December 1998 to March 1999.

Table 7-1. Average ambient air and burrow temperature data (°C) for six sites sampled December 1997 to March 1998.

Burrow Site #15 (Metal Culvert, Transition ecoregion) Depth: 31 cm Length: 6.1 m Elevation: 1323 m

n=	Ambient	Mean	Max	Min	Stdev	Burrow	Mean	Max	Min	Stdev
1678	Total (12/10/97-3/25/98)	5.4	27.1	-6.3	5.9	Total (12/10/97-3/25/98)	6.0	11.7	2.8	1.6
341	DEC 10-31	3.5	18.2	-6.3	5.1	DEC 10-31	4.7	6.6	2.8	0.8
496	JAN	4.8	19.8	-4.8	5.3	JAN	5.8	6.6	4.1	0.7
448	FEB	3.7	14.8	-3.8	3.9	FEB	5.4	6.6	4.1	0.7
393	MAR 1-25	9.7	27.1	-4.3	6.9	MAR 1-25	8.3	11.7	5.3	1.6

Burrow Site #2 (Metal Culvert, Transition ecoregion) Depth: 51 cm Length: 6.1 m Elevation: 1341 m

n=	Ambient	Mean	Max	Min	Stdev	Burrow	Mean	Max	Min	Stdev
1679	Total (12/10/97-3/25/98)	5.4	28.3	-8.3	6.8	Total (12/10/97-3/25/98)	6.2	16.3	1.1	2.6
343	DEC 10-31	2.5	20.2	-8.3	6.1	DEC 10-31	3.6	5.8	1.1	0.9
496	JAN	4.7	22.4	-8.3	6.4	JAN	5.5	8.2	2.4	1.2
448	FEB	4.3	16.7	-3.3	4.4	FEB	5.7	7.4	3.3	1.0
392	MAR 1-25	10.1	28.3	-3.8	7.7	MAR 1-25	9.8	16.3	4.5	2.4

Burrow Site #14 (Metal Culvert, Transition ecoregion) Depth: 79 cm Length: 6.1 m Elevation: 1295 m Occupied

n=	Ambient	Mean	Max	Min	Stdev	Burrow	Mean	Max	Min	Stdev
400	Total (1/27-2/21/98)	4.6	22.1	-3.3	4.9	Total (1/27-2/21/98)	7.6	8.6	7.0	0.5
73	JAN 27-31	5.9	22.1	-3.3	7.1	JAN 27-31	7.1	7.4	7.0	0.1
327	FEB 1-21	4.3	16.7	-3.3	4.2	FEB 1-21	7.7	8.6	7.0	0.5

Burrow Site #36 (Natural Soil Burrow, Mojave Desert ecoregion) Depth: 103 cm Length: 2.4 m Elevation: 1036 m

n=	Ambient	Mean	Max	Min	Stdev	Burrow	Mean	Max	Min	Stdev
1678	Total (12/10/97-3/25/98)	7.2	28.3	-5.3	6.0	Total (12/10/97-3/25/98)	11.7	14.1	9.8	0.8
345	DEC 10-31	5.1	22.1	-5.3	5.3	DEC 10-31	12.6	14.1	10.2	0.8
496	JAN	6.4	23.6	-3.8	5.7	JAN	11.7	13.3	10.2	0.6
448	FEB	6.1	17.4	-1.9	4.1	FEB	11.3	12.1	9.8	0.5
389	MAR 1-25	11.4	28.3	-1.4	6.9	MAR 1-25	11.4	13.3	9.8	0.8

Burrow Site #13 (Metal Culvert, Transition ecoregion) Depth: 118 cm Length: 6.1 m Elevation: 1286 m Occupied

n=	Ambient	Mean	Max	Min	Stdev	Burrow	Mean	Max	Min	Stdev
1434	Total (12/10/97-3/10/98)	3.7	19.0	-7.8	5.6	Total (12/10/97-3/10/98)	7.7	9.4	6.6	0.5
342	DEC 10-31	3.1	18.6	-6.8	5.5	DEC 10-31	7.8	9.4	6.6	0.8
496	JAN	3.7	19.0	-7.8	6.3	JAN	7.7	8.2	7.0	0.3
448	FEB	3.6	14.8	-5.3	4.3	FEB	7.4	7.8	6.6	0.4
148	MAR 1-10	5.5	17.8	-5.8	6.3	MAR 1-10	7.7	8.2	6.6	0.5

Burrow Site #30 (Caliche Wash Burrow, Transition ecoregion) Depth: 160 cm Length: 2.1 m Elevation: 1250 m Occupied

n=	Ambient	Mean	Max	Min	Stdev	Burrow	Mean	Max	Min	Stdev
1420	Total (12/10/97-2/26/98; 3/4-3/15/98)	6.4	27.5	-8.9	6.8	Total (12/10/97-2/26/98; 3/4-3/15/98)	11.2	14.4	8.2	1.3
344	DEC 10-31	5.6	24.0	-8.9	7.5	DEC 10-31	13.0	14.4	12.1	0.7
496	JAN	6.2	24.8	-6.3	6.8	JAN	11.3	12.1	10.6	0.4
402	FEB 1-26	5.5	19.4	-3.8	4.8	FEB 1-26	10.3	11.3	9.4	0.5
178	MAR 4-15	10.4	27.5	-2.4	8.0	MAR 4-15	9.5	11.3	8.2	0.6

Table 7-2. Average ambient air and burrow temperature data (ºC) for six sites sampled December 1998 to March 1999.

Burrow Site #2 (Metal Culvert, Transition ecoregion) Depth: 51 cm Length: 6.1 m Elevation: 1341 m

n=	Ambient	Mean	Max	Min	Stdev	n=	Burrow	Mean	Max	Min	Stdev
1785	Total (12/16/98-2/28/99*)	6.3	27.9	-12.8	8.1	1660	Total (12/16/98-3/30/99)	8.6	16.3	1.1	3.2
369	DEC 16-31	4.7	26.7	-12.8	9.1	246	DEC 16-31	5.6	9.4	1.1	2.3
744	JAN	6.0	25.2	-9.9	7.5	496	JAN	6.9	8.6	4.1	1.0
672	FEB	7.5	27.9	-8.3	8.0	448	FEB	7.7	12.1	3.7	1.9
	*=hourly measurement					470	MAR 1-30	12.9	16.3	9.4	1.6

Burrow Site #41 (Metal Culvert, Transition ecoregion) Depth: 59 cm Length: 3.0 m Elevation: 1286 m Occupied

n=	Ambient	Mean	Max	Min	Stdev	n=	Burrow	Mean	Max	Min	Stdev
281	Total (12/16/98-1/3/99)	4.2	24.8	-11.7	8.3	281	Total (12/16/98-1/3/99)	6.3	8.6	4.5	1.4
246	DEC 16-31	3.9	24.8	-11.7	8.6	246	DEC 16-31	6.2	8.6	4.5	1.5
35	JAN 1-3	6.9	15.9	-0.1	5.2	35	JAN 1-3	6.6	7.0	6.6	0.1

Burrow Site #14 (Metal Culvert, Transition ecoregion) Depth: 66 cm Length: 3.5 m Elevation: 1295 m Occupied

n=	Ambient	Mean	Max	Min	Stdev	n=	Burrow	Mean	Max	Min	Stdev
467	Total (12/16/98-1/14/99)	4.5	24.8	-12.2	8.3	467	Total (12/16/98-1/14/99)	7.9	9.8	6.2	0.9
247	DEC 16-31	3.4	24.8	-12.2	8.8	247	DEC 16-31	7.9	9.8	6.2	1.2
220	JAN 1-14	5.7	22.1	-6.3	7.6	220	JAN 1-14	7.8	8.2	7.4	0.1

Burrow Site #36 (Natural Soil Burrow, Mojave Desert ecoregion) Depth: 103 cm Length: 2.4 m Elevation: 1036 m Occupied

n=	Ambient	Mean	Max	Min	Stdev	n=	Burrow	Mean	Max	Min	Stdev
1630	Total (12/16/98-1/17/99; 1/19-3/30/99)	9.6	29.1	-8.9	7.6	1630	Total (12/16/98-1/17/99; 1/19-3/30/99)	13.5	15.6	11.7	0.7
249	DEC 16-31	6.5	26.7	-8.9	8.5	249	DEC 16-31	13.8	15.6	11.7	0.9
463	JAN 1-17; 19-31	8.1	25.2	-3.3	6.4	463	JAN 1-17; 19-31	13.3	14.1	12.1	0.4
448	FEB	8.9	27.1	-4.8	7.0	448	FEB	12.8	13.3	11.7	0.4
470	MAR 1-30	13.2	29.1	-1.0	7.4	470	MAR 1-30	14.1	15.2	12.9	0.4

Burrow Site #30 (Caliche Wash Burrow, Transition ecoregion) Depth: 160 cm Length: 3.0 m Elevation: 1250 m Occupied

n=	Ambient	Mean	Max	Min	Stdev	n=	Burrow	Mean	Max	Min	Stdev
961	Total (12/16/98-1/28/99; 2/2-2/19/99)	7.5	31.4	-11.7	8.0	961	Total (12/16/98-1/28/99, 2/2-2/19/99)	12.5	14.4	10.6	1.0
248	DEC 16-31	6.7	31.4	-11.7	9.4	248	DEC 16-31	13.7	14.4	12.9	0.5
441	JAN 1-28	7.7	25.6	-9.4	7.8	441	JAN 1-28	12.5	12.9	11.7	0.3
272	FEB 2-19	7.9	24.0	-5.3	6.6	272	FEB 2-19	11.2	11.7	10.6	0.3

Burrow Site #9 (Roadcut Burrow, Great Basin Desert ecoregion) Depth: 183 cm Length: 1.8 m Elevation: 1615 m

n=	Ambient	Mean	Max	Min	Stdev	n=	Burrow	Mean	Max	Min	Stdev
1458	Total (12/16-12/29/98; 1/11-3/30/99)	6.2	25.9	-14.7	8.0	1382	Total (12/16-12/29/98; 1/11-3/25/99)	9.9	13.7	5.8	1.3
206	DEC 16-29	3.1	25.9	-14.7	9.4	206	DEC 16-29	11.4	13.7	7.8	1.3
330	JAN 11-31	4.7	22.4	-9.9	6.7	330	JAN 11-31	10.5	12.1	6.2	1.4
448	FEB	5.9	24.0	-8.9	7.4	448	FEB	8.9	10.2	5.8	0.8
474	MAR 1-30	9.0	25.6	-5.3	7.9	398	MAR 1-25	9.7	10.6	7.8	0.6

sites, #36 and #30, had the warmest average burrow temperatures and the two shallowest burrow sites, #15 and #2, had the coldest average burrow temperatures (Table 7-1).

Average ambient air temperature of all six sites was 5.5 °C and ranged from 3.7 °C at Burrow Site #13 to 7.2 °C at Burrow Site #36. As expected, ambient air temperature fluctuated greatly and much more than temperatures inside the burrows as evidenced by the large standard deviations for ambient air versus burrow temperature (Table 7-1).

For the study period, the average difference between ambient air temperature and the temperature inside the burrow was 3.0 °C and ranged from 0.6 °C at Burrow Site #15 to 4.8 °C at Burrow Site #30 (Figure 7-4). In other words, on average it was 3.0 °C warmer inside a burrow than outside. The difference between average burrow temperature and average ambient air temperature at Burrow Sites #36, #13, and #30 (4.5 °C , 4.0 °C , and 4.8 °C, respectively) was substantially greater as compared to Burrow Sites #15 and #2 (0.6 °C and 0.8 °C, respectively).

From December 1997 to March 1998, owls occupied three of the six Burrow Sites (#14, #13, and #30, the three deepest sites in the transition ecoregion) (Table 7-3). Duration and timing of owl occupancy varied greatly. Average burrow temperature during all or a portion of time when owls occupied a burrow averaged 8.5 °C and ranged from 7.6 °C at Burrow Site #14 to 9.6 °C at Burrow Site #30. For corresponding time periods, the average ambient air temperature averaged

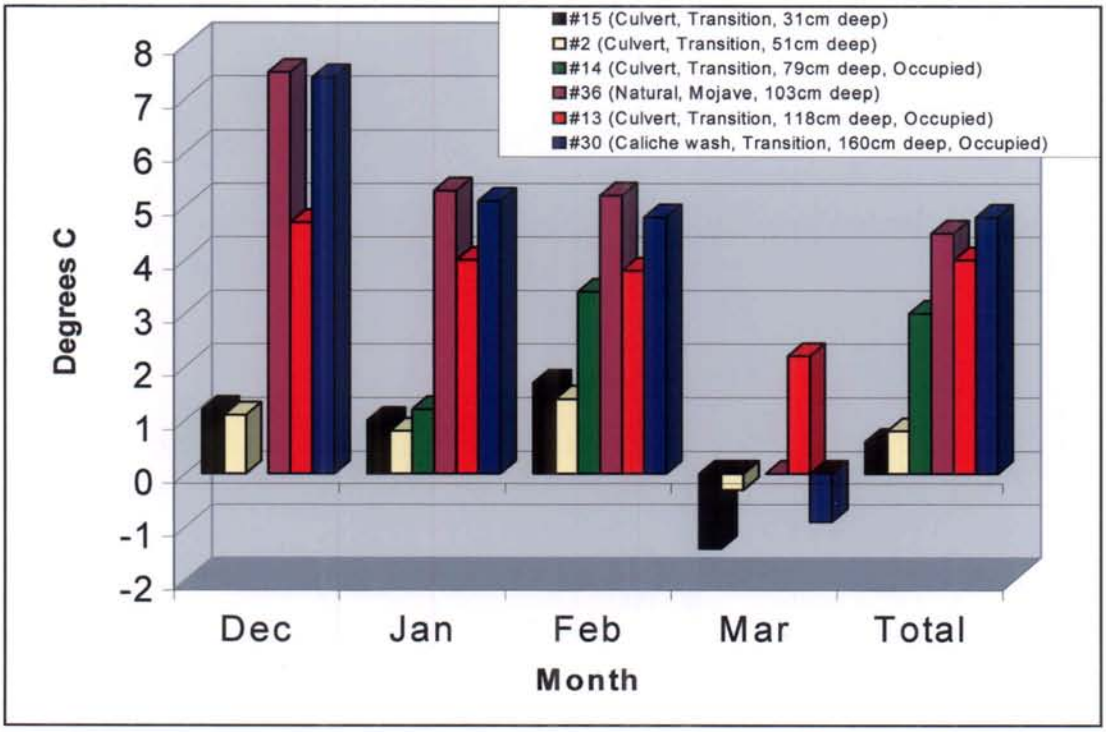

Figure 7-4. Average differences between burrow and ambient air temperature by site and month for six burrow sites monitored from December 1997 to March 1998.

Table 7-3. Burrow site characteristics, owl occupancy information, and temperature data (°C) from December to March, 1997-1998 and 1998-1999.

Burrow Site	1997-98	1997-98		Ave. Burrow Temp.	Ave. Ambient Temp.	Burrow-
(Type, Ecoregion)	Depth* (cm)	Length** (m)	Owl occupancy	(dates of data averaged)	(dates of data averaged)	Ambient
#15 (Culvert, transition)	31	6.1	No owls	**5.7** (1/27-2/21/98)***	N/A	N/A
#2 (Culvert, transition)	51	6.1	No owls	**5.9** (1/27-2/21/98)***	N/A	N/A
#14 (Culvert, transition)	79	6.1	Owl (1/27-3/25/98)	**7.6** (1/27-2/21/98)	**4.6** (1/27-2/21/98)	**3.0**
#36 (Natural, Mojave Desert)	103	2.4	No owls	**11.5** (1/27-2/21/98)***	N/A	N/A
#13 (Culvert, transition)	118	6.1	Owl (12/10-12/22/97)	**8.4** (12/10-12/22/97)	**2.5** (12/10-12/22/97)	**5.9**
#30 (Caliche wash, transition)	160	2.1	Owl (2/17-3/25/98)	**9.6** (2/17-2/26;3/4-3/15/98)	**7.9** (2/17-2/26;3/4-3/15/98)	**1.7**
	1998-99	**1998-99**				
	Depth* (cm)	**Length** (m)**				
#2 (Culvert, transition)	51	6.1	No owls	**6.2** (12/16/98-1/14/99)***	N/A	N/A
#41 (Culvert, transition)	59	3.0	Owl (12/16-12/22/98)	**7.9** (12/16-12/22/98)	**3.4** (12/16-12/22/98)	**4.5**
#41 (Culvert, transition)	59	3.0	Owl (3/3-3/30/99)	No data	N/A	N/A
#14 (Culvert, transition)	66	3.5	Owl (12/16/98-3/30/99)	**7.9** (12/16/98-1/14/99)	**4.5** (12/16/98-1/14/99)	**3.4**
#36 (Natural, Mojave Desert)	103	2.4	Owl 12/16-12/22/98	**14.7** (12/16-12/22/98)	**6.5** (12/16-12/22/98)	**8.2**
#36 (Natural, Mojave Desert)	103	2.4	Owl 3/17-3/30/99	**14.4** (3/17-3/30/99)	**14.9** (3/17-3/30/99)	**-0.5**
#30 (Caliche wash, transition)	160	3.0	Owl (1/6-3/30/99)	**12.0** (1/6-1/28; 2/2-2/19/99)	**7.8** (1/6-1/28; 2/2-2/19/99)	**4.2**
#9 (Roadcut, Great Basin Desert)	183	1.8	No owls	No data	N/A	N/A

*=Depth from the ground surface to the emplaced data logger

**=Distance the data logger was emplaced inside the burrow

***=Dates subjectively chosen for best comparison of temperatures with burrows occupied by owls

N/A=Not applicable due to lack of owl occupancy or temperature data for comparing with burrow temperature

5.0 °C and ranged from 2.5 °C at Burrow Site #13 to 7.9 °C at Burrow Site #30. The difference between average burrow temperature and ambient air temperature averaged 3.5 °C and ranged from 1.7 °C at Burrow Site #30 to 5.9 °C at Burrow Site #13. Average burrow temperature was 1.7 °C and 1.9 °C warmer at Burrow Site #14 (owl present) than at Burrow Site #2 and Burrow Site #15 (no owls present), respectively. All three of these were culvert burrows in the transition ecoregion. In contrast, average burrow temperature was 3.9 °C colder at Burrow Site #14 (owl present) than at Burrow Site #36 (no owl present) in the Mojave Desert ecoregion.

December 1998 to March 1999. Average burrow temperature of all six sites was 9.8 °C and ranged from 6.3 °C at Burrow Site #41 to 13.5 °C at Burrow Site #36. Two of the deeper burrow sites, #36 and #30, had the warmest average burrow temperatures. The two shallowest burrows, #2 and #41, had the coldest burrow temperatures during December. Due to missing data for Burrow Sites #41 and #14, it is not possible to compare coldest average burrow temperatures throughout the monitoring period (Table 7-2).

Average ambient air temperature of all six sites was 6.4 °C and ranged from 4.2 °C at Burrow Site #41 to 9.6 °C at Burrow Site #36. Again as expected, ambient air temperature fluctuated greatly and much more than temperatures inside the burrows as evidenced by the large standard deviations for ambient air vs. burrow temperature (Table 7-2).

For the study period, the average difference between ambient air temperature and the temperature inside the burrow for five sites was 3.6 °C and ranged from 2.1 °C at Burrow Site #41 to 5.0 °C at Burrow Site #30 (Figure 7-5). In other words, on average it was 3.6 °C warmer inside a burrow than outside.

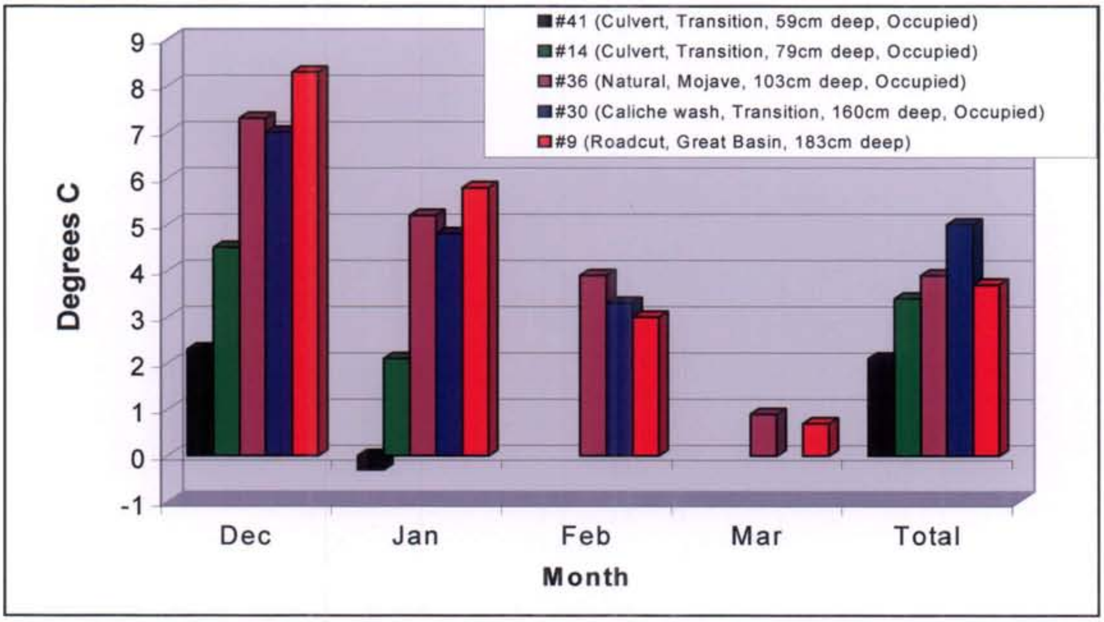

Figure 7-5. Average differences between burrow and ambient air temperature by site and month for five burrow sites monitored from December 1998 to March 1999.

From December 1998 to March 1999 owls occupied four of the six Burrow Sites (#41, #14, #36, and #30) for at least a portion of the time (Table 7-3). Duration and timing of owl occupancy varied greatly. Average burrow temperature during all or a portion of time when owls occupied a burrow was 11.4 °C and ranged from 7.9 °C at Burrow Sites #41 and #14 to 14.7 °C at Burrow Site #36. For corresponding time periods, the average ambient air temperature was 7.4 °C and ranged from 3.4 °C at Burrow Site #41 to 14.9°C at Burrow Site #36. The average difference between average burrow temperature and ambient air temperature was 4.0 °C and ranged from -0.5 °C at Burrow Site #36 (March 17-30, 1999) to 8.2 °C at Burrow Site #36 (December 16-22, 1998). Therefore, the average temperature inside a burrow was generally warmer than average ambient air temperature. Average burrow temperature was again 1.7 °C warmer in Burrow #14 (owl present) than in Burrow #2 (no owl present).

7.4 Discussion

Because of unequal time periods (missing data) and small sample size, it is not possible to statistically analyze these data (e.g., correlate burrow depth with burrow temperature). Also, direct comparisons among burrows should be made cautiously for the same reasons. However, some important and meaningful points can be made based on these data.

Burrow depth does influence burrow temperature with deeper burrows having warmer average temperatures and shallower burrows having colder average temperatures during the winter months. Latitude appears to influence the average burrow temperature more than depth or elevation. The burrow site (#36) with the warmest average burrow temperature during both study periods was also the southernmost site and the site at the lowest elevation, but it was not the deepest. Although Burrow Site #30 was at a comparable elevation to sites in Yucca Flat, average burrow temperature was substantially warmer at #30 than at the Yucca Flat sites, and Burrow Site #30 is the second southernmost site, over 30 km south of the Yucca Flat sites. Burrow Site #30 is also located in a washbank with a southern aspect, which most likely influenced internal burrow temperature also. Furthermore, cold air tends to settle in enclosed valleys such as Yucca Flat, so physiography may help explain why burrow temperatures are colder in Yucca Flat compared to other sites at comparable elevations. Many other factors may influence burrow temperature including but not limited to internal burrow architecture, burrow length, number of openings, aspect, substrate, and presence of animals (including owls) or any combination of these factors. More work is needed to determine how these factors influence burrow temperature.

Regardless of depth, burrows provided a warmer and more thermally stable environment through the winter as compared to being exposed to ambient air temperatures. Millsap and Millsap (1987) studying barn owl (*Tyto alba*) burrow temperatures in Colorado also determined that burrow temperatures were more thermally stable than ambient temperatures. Averaging across both study periods, the internal temperature of a burrow was 3.3 °C warmer than ambient air temperature. Generally, the biggest difference between average burrow and ambient air temperature occurred in December and was least in March. In some cases, the average March burrow temperature was cooler than the ambient air temperature. Even though burrows were not monitored during the months of April to November, it is expected that average burrow temperature would be cooler than ambient air temperature from March/April to

October/November, at which point burrow temperature would again become warmer than ambient air temperature.

The duration and timing of owl occupancy varied greatly during both study periods (Table 7-3). Also, due to data loggers being pulled out of burrows and data logger malfunctions, there is some missing data. For these two reasons, it is difficult to determine if owls preferentially selected winter burrows that were warmer than other available burrows. A slight trend for warmer temperatures (1.7 °C) and owl occupation at Burrow Site #14 versus Burrow Site #2 (no owls) during both years may suggest a preference for a deeper, warmer burrow at least within Yucca Flat. However, it is not known if this small difference is biologically significant enough to influence behavior. Owls were not detected in burrows where the recorded minimum burrow temperature was less than about 6.0 °C (Figures 7-1 and 7-2, Table 7-3). During December 1998, an owl was present at Burrow Site #41 from December 16 to at least December 22 when it appeared to have left because this is the last date fresh sign was detected. This time period coincides with a decline in burrow temperature to 6.2 °C on December 22 and a decline to a low of 4.5 °C on December 24. Thus, owls may select burrows that do not get colder than between 4.5 °C and 6.2 °C and may leave if temperatures drop below this threshold.

Factors other than burrow temperature (e.g., prey availability) influence winter burrow selection because during 1997-98, the warmest burrow (#36) had no owl occupancy. Burrow Site #36 is located in the Mojave Desert ecoregion which has low owl use, especially during the winter months (See 3.0).

Owls were present in burrows with average temperatures ranging from 7.6 °C to 14.7 °C (average over both study periods 10.3 °C). It is not known if or to what degree the presence of an owl or other animal (e.g., rabbit) has on the internal burrow temperature. For corresponding time periods of average burrow temperature measurements, average ambient air temperature ranged from 2.5 °C to 14.9 °C (average over both study periods 6.5 °C). Differences between average burrow temperature and average ambient air temperature ranged from –0.5 °C to 8.2 °C (average over both study periods 3.8 °C). On the average, an owl in a burrow was in an environment 3.8 °C warmer than ambient air. Coulombe (1970) determined that an owl maintains an average body temperature of 38.0 °C when ambient temperature is 0-38.0 °C. It is logical to assume that the colder it gets the more energy an owl will need to expend to maintain its body temperature. Thus, an owl in a burrow will conserve a lot more energy over the winter months (especially in December) compared to an owl exposed constantly to ambient air conditions. Warmer burrow temperatures during the winter may also affect owl behavior. Typically, owls are not seen aboveground much during winter. Owls may be conserving energy by remaining in their warmer, more thermally stable burrows rather than exposing themselves to the colder, widely fluctuating ambient air temperatures. More work is needed to determine factors in owl winter burrow selection. The concepts discussed here apply to other animals that utilize these burrows as well and are not restricted only to owls.

Some problems were encountered during this study. One problem was that owls or other animals at some burrows pulled the data logger out onto the burrow apron. There is not much we could do to stop this from happening. The best way to minimize loss of data from this problem is to check the burrows at least twice a week. The other problem encountered was data logger malfunction. It is important to put a new battery in the data logger at the beginning of each use. Also, it may get rather humid inside the burrow so it may be helpful to put the data logger inside a waterproof container before emplacement. Another idea to ensure good data would be to use two data loggers instead of just one at each sampling spot.

8.0 SPECIES MANAGEMENT

8.1 Introduction

Bechtel Nevada biologists, under the direction and funding of NNSA/NSO, conduct a variety of wildlife management tasks on the NTS as part of the NTS Ecological Monitoring and Compliance (EMAC) Program. The overall objective of the EMAC Program is to protect the biological resources of the NTS while supporting the mission of DOE to operate a national test site. Meeting this objective involves developing procedures that ensure that NTS activities comply with state and federal wildlife and environmental protection regulations, and at the same time, allow operation of the NTS.

Over the past four years, owl monitoring tasks have been identified and supported through the EMAC program. Data gathered on the owl's distribution, abundance, and life history on the NTS have been incorporated into management procedures that enhance wildlife protection and environmental compliance goals of the EMAC Program.

The objectives of this section are to: (1) present the current legal status of the owl and NNSA/NSO's directives that influence owl management on the NTS, (2) describe owl management actions developed from data presented in this report, (3) discuss the effects of NTS activities on the owl, and (4) describe the EMAC Owl Monitoring Program.

8.2 Legal Status and Management Requirements

The western burrowing owl is federally protected under the Migratory Bird Treaty Act (MBTA). The MBTA prohibits the harm or possession of any migratory bird, their nest, or eggs without express authorization by the Secretary of the Interior. The U.S. Fish and Wildlife Service (USFWS) also classifies the western burrowing owl as a National Bird of Conservation Concern (USFWS, 2002). In Nevada, this species is classified as Protected by the state (as are all raptors) and as a proposed Sensitive species by the U.S. Bureau of Land Management.

In January 2001, Executive Order 13186 mandated that federal agencies take certain actions to further implement the MBTA (Federal Register, 2001). Each Federal agency ". . . . taking actions that have, or are likely to have, a measurable negative effect on migratory bird populations" was directed to develop and implement, within two years, a Memorandum of Understanding with the Fish and Wildlife Service that promotes the conservation of migratory bird populations. Also, each agency was directed to support the conservation intent of the MBTA by integrating bird conservation principles, measures, and practices into agency activities and by avoiding or minimizing, to the extent practicable, adverse impacts on migratory bird resources when conducting agency actions.

8.3 Management Actions

To minimize adverse impacts to all sensitive species (including owls) and the illegal take of protected wildlife on the NTS, biologists survey lands where proposed projects will occur. Most projects are construction projects where vegetation is removed and soils are removed, recontoured, or compacted. These surveys are called preactivity surveys and they have been routinely conducted for all new projects sited in previously undisturbed areas of the NTS. If sensitive species (including owls) or important resources (such as nest burrows) are found during a preactivity survey, recommendations are provided to mitigate potential impacts.

As a result of owl monitoring under the EMAC Program, the scope of preactivity surveys has expanded to include lands which have been previously disturbed. Owls inhabit disturbed areas and use partially buried culverts and pipes and predator burrows dug into human-made soil mounds and roadcuts. Cleanup and restoration activities are now conducted at many previously disturbed areas on the NTS under NNSA/NSO's Environmental Restoration Program. Culverts, pipes, human-made excavations, and soil mounds are searched for owl sign and presence when cleanup projects may disturb such structures, or where human activities may be in close proximity to these structures.

The scope of preactivity surveys has also expanded to include searching for owls at proposed project sites in the Great Basin ecoregion of the NTS. Prior to this study, owls were not expected to occur in this region of the NTS. Also, preactivity surveys are conducted during all months of the year because data from this study document that owls occur year round on the NTS. All natural burrows and human-made potential burrow structures found during preactivity surveys are searched. Burrows are destroyed only when they are confirmed to be unoccupied.

Based on reproduction monitoring data, it is known that owls breed and rear young on the NTS from March to August. During this period, owls are most vulnerable to land disturbance impacts because eggs or young owls are present, and the largest number of owls are present. Although it has yet to occur on the NTS, if a proposed project site threatened active owl burrows during the breeding season, it would be recommended that the project's land-disturbing activities be scheduled for the fall and winter. If an active nest burrow is found and the project cannot be delayed until the fall or winter, biologists will consult with the USFWS to discuss possible actions to relocate eggs, unfledged young, or adults. Literature suggests that artificial burrows can be constructed nearby (Collins and Landry, 1977; Trulio, 1995a; Trulio 1995b; Belthoff and Smith, 2003), usually within 100 m of an occupied burrow (Trulio, 1995a; Trulio 1995b), to relocate displaced owls. If an active owl burrow is threatened by a project outside the breeding season, biologists will consult with USFWS to discuss possible mitigation actions.

The flushing distance data collected during this monitoring study indicates that a buffer zone of 60 m should be maintained around occupied owl burrows to ensure that owls are not harassed, particularly during the breeding season. Project personnel will be told to remain at least 60 m away from occupied burrows if walking or driving in their vicinity. This recommendation does not include normal vehicle traffic along NTS roads. This recommended buffer distance may change depending on the type and level of disturbance that is proposed.

8.4 Effects of NNSA/NSO Activities on the Owl

Many project construction and site cleanup activities on the NTS may threaten owls. Owl burrows may be crushed and owls may be killed during heavy equipment use during the clearing of vegetation, blading of surface soils, compacting of soils, off-road driving, and staging of equipment and materials. Even off-road driving of light vehicles to and from the project site may threaten harm to owls in their burrows.

Since 1979, over 1,400 sites have been surveyed for land-disturbing projects throughout all ecoregions of the NTS. At about 200 sites, active and inactive animal burrows have been found, including burrows of tortoises, predators (badger, coyote, kit fox), and owls, as determined by their size, shape, and presence of animals or their sign, such as scat or pellets. Owl burrows were only found at 8 of these 200 project sites. They included nine burrows: four occupied burrows and one unoccupied earthen burrow and one occupied and three unoccupied pipe burrows. Two unoccupied burrows found could not be avoided and were destroyed. Based on the results of preactivity surveys, land-disturbing activities on the NTS since 1979 have not negatively impacted owls. This is because very few owls and owl burrows occur on the NTS, or at least they are rarely found at project sites.

Some activities on the NTS may directly threaten owls. Since 1990, sightings of dead birds have been reported to biologists and a bird mortality database has been maintained. These reports are investigated to determine if NTS facilities/activities need to be modified to prevent or reduce the incidence of bird mortality. In 2002, the first and only western burrowing owl mortality was recorded. The owl was found on a paved road and appeared to have been hit by a vehicle.

NTS activities are not expected to have any indirect adverse effect on owls. Based on the owl pellet analyses from this study and from other literature, owls are known to have a generalist feeding strategy, taking prey opportunistically. They prey on insects and other invertebrates, small rodents, reptiles, and even other birds. They are not reliant on only a few, selected prey species. This characteristic makes them less susceptible to any adverse impacts indirectly related to human activities. Regional climatic events such as prolonged drought would affect owl abundance and population stability on the NTS more than any human factors.

Land construction activities on the NTS may enhance owl habitat. This study indicates that owls may prefer to occupy, breed, and rear young in pipe and culvert burrows rather than in earthen burrows. Such pipes and culverts, prominent at historic underground nuclear event sites scattered throughout Yucca Flat, may be a habitat feature which favors an increased abundance of owls on the NTS. The open habitat created at these historic sites may also serve to attract owls.

Based on this impact assessment and on the assumption that preactivity surveys will continue to be conducted on the NTS, NNSA/NSO activities will not negatively affect western burrowing owls. Pursuant to Executive Order 13186 (see Section 8.2), a Memorandum of Understanding between NNSA/NSO and the USFWS is not necessary to ensure the population stability of this species of migratory bird on the NTS. The EMAC Program, which includes the preactivity survey process, complies with this Executive Order since it ". . . supports the conservation intent of the MBTA by integrating bird conservation principles, measures, and practices into agency activities and by avoiding or minimizing, to the extent practicable, adverse impacts on migratory bird resources when conducting agency actions."

8.5 EMAC Owl Monitoring Program

Owl reproduction should be monitored once every three to five years using a remote camera system. The number of breeding pairs and young will be recorded. Attempts will be made to periodically search ecoregions for new burrow sites and to sample known burrows to assess population trends over time. Due to the small number of owls on the NTS, population trend data are not statistically robust, however they are the best available and may be useful in future impact assessments. Preactivity surveys will continue to be performed year-round for proposed land-disturbing activities on both undisturbed and previously disturbed areas. New locations of owl sightings and owl burrows will be recorded.

If the western burrowing owl becomes listed under the Endangered Species Act, a biological assessment of the effects of NNSA/NSO activities on the owl will be prepared and consultation with the USFWS will be initiated. The biological assessment will include data collected under the EMAC Owl Monitoring Program.

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Appendix A

Physical Burrow Attributes and Photos of Owl Burrows Monitored on the Nevada Test Site from November 1997 through May 2002.

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Burrow Site 1: Burrows A-E

Location: Area 2, 2-07 Road, 2L-20 Pad
Ecoregion: Transition
Elevation: 1323 m
Topography: Basin floor
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Culvert
Aspect: 270° (W)
Height: 19 cm
Width: 35 cm

Burrow B
Culvert
Aspect: 10° (N)
Height: 13 cm
Width: 25 cm

Burrow C
Culvert
Aspect: 90° (E)
Height: 25 cm
Width: 40 cm

Burrow D
Pipe
Aspect: 120° (SE)
Height: 15 cm
Width: 16 cm

Burrow E
Culvert (Filled In)
Aspect: 190° (S)
Height: 8 cm
Width: 16 cm

Burrow Site 2: Burrows A and B

Location: Area 2, 2-04 and 2L Roads Intersection
Ecoregion: Transition
Elevation: 1341 m
Topography: Piedmont Slope
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Culvert
Aspect: 270° (W)
Height: 15 cm
Width: 35 cm

Burrow B
Culvert
Aspect: 90° (E)
Height: 14 cm
Width: 34 cm

Burrow Site 3: Burrows A-C

Location: Area 2, 2-04 Road, West
Ecoregion: Transition
Elevation: 1344 m
Topography: Piedmont Slope
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Culvert
Aspect: 20° (N)
Height: 20 cm
Width: 38 cm

Burrow B
Culvert
Aspect: 200° (S)
Height: 19 cm
Width: 38 cm

Burrow C
Culvert
Aspect: 20° (N)
Height: 12 cm
Width: 35 cm

Burrow Site 4: Burrows A-E

Location: Area 2, 2-04 Road, East
Ecoregion: Transition
Elevation: 1338 m
Topography: Piedmont Slope
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Culvert
Aspect: 270° (W)
Height: 12 cm
Width: 25 cm

Burrow B
Culvert
Aspect: 270° (W)
Height: 12 cm
Width: 32 cm

Burrow C
Culvert
Aspect: 60° (NE)
Height: 18 cm
Width: 35 cm

Burrow D
Culvert
Aspect: 60° (NE)
Height: 15 cm
Width: 32 cm

Burrow E
Earthen Burrow
Aspect: 200° (S)
Height: 11 cm
Width: 25 cm

Burrow Site 5: Burrows A-D

Location: Area 9, 9-01 Road, 2G-24 #2
Elevation: 1305 m
Ecoregion: Transition
Topography: Basin Floor
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Culvert
Aspect: 270° (W)
Height: 14 cm
Width: 34 cm

Burrow B
Culvert
Aspect: 90° (E)
Height: 13 cm
Width: 27 cm

Burrow C
Culvert
Aspect: 260° (W)
Height: 28 cm
Width: 38 cm

Burrow D
Culvert
Aspect: 80° (E)
Height: 15 cm
Width: 37 cm

Burrow Site 6: Burrows A and B

Location: Area 9, 9-01 Road, 2G-24 #1
Ecoregion: Transition
Elevation: 1305 m
Topography: Basin Floor
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Culvert
Aspect: 290° (W)
Height: 15 cm
Width: 33 cm

Burrow B
Culvert
Aspect: 110° (E)
Height: 12 cm
Width: 32 cm

Burrow Site 7: Burrows A-C

Location: Area 9, 9-01 Road, 2G-24 #3
Ecoregion: Transition
Elevation: 1298 m
Topography: Basin floor
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrows A & B
Culvert
Aspect: 20° (N)
Height: 10 (A), 17 (B) cm
Width: 29 (A), 32 (B) cm

Burrow C
Culvert
Aspect: 200° (S)
Height: 17 cm
Width: 34 cm

Burrow Site 8: Burrows A-C

Location: Area 2, 2L Road, 2L-5
Ecoregion: Transition
Elevation: 1372 m
Topography: Piedmont Slope
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Culvert
Aspect: 20° (N)
Height: 18 cm
Width: 34 cm

Burrow B
Earthen (Filled In)
Aspect: 300° (NW)
Height: 12 cm
Width: 18 cm

Burrow C
Culvert
Aspect: 200° (S)
Height: 23 cm
Width: 35 cm

Burrow Site 9: Burrows A-C

Location: Area 18, 18-03 Road #1
Ecoregion: Great Basin Desert
Elevation: 1615 m
Topography: Piedmont Slope
Vegetation: *Artemisia tridentata-Chrysothamnus viscidiflorus* Shrubland Association

Burrow A
Roadcut Earthen (Filled In)
Aspect: 190° (S)
Height: 22 cm
Width: 70 cm

Burrow B
Roadcut Earthen
Aspect: 40° (NE)
Height: 15 cm
Width: 27 cm

Burrow C
Roadcut Earthen
Aspect: 160° (S)
Height: 11 cm
Width: 30 cm

Burrow Site 10: Burrows A and B

Location: Area 9, Old Mercury Highway
Ecoregion: Transition
Elevation: 1281 m
Topography: Piedmont Slope
Vegetation: *Ephedra nevadensis-Grayia spinosa* Shrubland Association

Burrow A
Culvert
Aspect: 30° (NE)
Height: 20 cm
Width: 35 cm

Burrow B
Culvert
Aspect: 220° (SW)
Height: 20 cm
Width: 37 cm

Burrow Site 11: Burrows A and B

Location: Area 18, 18-03 Road #2
Ecoregion: Great Basin Desert
Elevation: 1597 m
Topography: Piedmont Slope
Vegetation: *Artemisia tridentata-Chrysothamnus viscidiflorus* Shrubland Association

Burrow A
Roadcut Earthen
Aspect: 150° (SE)
Height: 25 cm
Width: 60 cm

Burrow B
Roadcut Earthen
Aspect: 360° (N)
Height: 15 cm
Width: 40 cm

Burrow Site 12: Burrow A

Location: Area 9, 9-01 Road, North of 9G-15 #1
Ecoregion: Transition
Elevation: 1286 m
Topography: Piedmont Slope
Vegetation: *Ephedra nevadensis-Grayia spinosa* Shrubland Association

Burrow A
Culvert (Inaccessible Area)
Aspect: 270° (W)
Height: 13 cm
Width: 33 cm

Burrow Site 13: Burrow A

Location: Area 9, 9-01 Road, 9G-15
Ecoregion: Transition
Elevation: 1286 m
Topography: Piedmont Slope
Vegetation: *Ephedra nevadensis-Grayia spinosa* Shrubland Association

Burrow A
Culvert
Aspect: 210° (SW)
Height: 16 cm
Width: 36 cm

Burrow Site 14: Burrows A-C

Location: Area 4, North of 4-04 Road
Ecoregion: Transition
Elevation: 1295 m
Topography: Basin Floor
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Culvert
Aspect: 100° (E)
Height: 12 cm
Width: 33 cm

Burrow B
Pipe (Filled In)
Aspect: 290° (W)
Height: 9 cm
Width: 27 cm

Burrow C
Culvert
Aspect: 240° (SW)
Height: 17 cm
Width: 35 cm

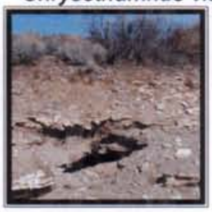
Burrow Site 15: Burrow A

Location: Area 9, Powerline Road, Pad
Ecoregion: Transition
Elevation: 1323 m
Topography: Piedmont Slope
Vegetation: *Coleogyne ramosissima-Ephedra nevadensis* Shrubland Association

Burrow A
Culvert
Aspect: 330° (NW)
Height: 20 cm
Width: 35 cm

Burrow Site 16: Burrow A

Location: Area 18, Airport Road #1
Ecoregion: Great Basin Desert
Elevation: 1530 m
Topography: Piedmont Slope
Vegetation: *Artemisia tridentata-Chrysothamnus viscidiflorus* Shrubland Association



Burrow A
Roadcut Earthen
Aspect: 180° (S)
Height: 12 cm
Width: 47 cm

Burrow Site 17: Burrows A-D
Location: Area 4, 4-04 Road #1
Ecoregion: Transition
Elevation: 1271 m
Topography: Basin Floor
Vegetation: Disturbance

Burrow A
Culvert
Aspect: 270° (W)
Height: 26 cm
Width: 35 cm

Burrow B
Culvert
Aspect: 90° (E)
Height: 24 cm
Width: 36 cm

Burrow C
Culvert
Aspect: 280° (W)
Height: 27 cm
Width: 36 cm

Burrow B
Culvert
Aspect: 100° (E)
Height: 17 cm
Width: 36 cm

Burrow Site 18: Burrow A
Location: Area 1, Orange Road, O-33, Wash
Ecoregion: Transition
Elevation: 1317 m
Topography: Wash
Vegetation: *Ephedra nevadensis-Grayia spinosa* Shrubland Association

Burrow A
Earthen (Filled In)
Aspect: 30° (NE)
Height: 12 cm
Width: 22 cm

Burrow Site 19: Burrows A and B
Location: Area 3, 3-03 and 3-05 Roads Intersection
Ecoregion: Transition
Elevation: 1225 m
Topography: Basin Floor
Vegetation Association: Miscellaneous

Burrow A
Pipe
Aspect: 100° (E)
Height: 15 cm
Width: 15 cm

Burrow B
Pipe
Aspect: 100° (E)
Height: 11 cm
Width: 15 cm

Burrow Site 20: Burrow A

Location: Area 3, North of 3-03 Road
Ecoregion: Transition
Elevation: 1228 m
Topography: Basin Floor
Vegetation: Miscellaneous

Burrow A
Pipe (Inaccessible Area)
Aspect: 90° (E)
Height: 15 cm
Width: 15 cm

Burrow Site 21: Burrows A and B
Location: Area 1, Orange Road, O-30 #1, Road
Ecoregion: Transition
Elevation: 1300 m
Topography: Piedmont Slope
Vegetation: *Ephedra nevadensis-Grayia spinosa* Shrubland Association

Burrow A
Earthen (Filled In)
Aspect: 230° (SW)
Height: 16 cm
Width: 23 cm

Burrow B
Earthen (Filled In)
Aspect: 200° (S)
Height: 11 cm
Width: 22 cm

Burrow Site 22: Burrows A and B

Location: Area 1, Orange Road, O-30 #3, Ditch
Ecoregion: Transition
Elevation: 1295 m
Topography: Piedmont Slope
Vegetation: *Coleogyne ramosissima-Ephedra nevadensis* Shrubland Association

Burrow A
Earthen
Aspect: 190° (S)
Height: 16 cm
Width: 44 cm

Burrow B
Earthen (Filled In)
Aspect: 190° (S)
Height: 15 cm
Width: 23 cm

Burrow Site 23: Burrow A

Location: Area 6, Orange Road, O-13
Ecoregion: Transition
Elevation: 1210 m
Topography: Basin Floor
Vegetation: *Atriplex confertifolia-Kochia americana* Shrubland Association

Burrow A
Earthen
Aspect: 50° (NE)
Height: 11 cm
Width: 24 cm

Burrow Site 24: Burrows A and B

Location: Area 6, Southeast Yucca Playa Edge
Ecoregion: Transition
Elevation: 1197 m
Topography: Basin Floor
Vegetation: *Atriplex confertifolia-Kochia americana* Shrubland Association

Burrow A
Earthen
Aspect: 325° (NW)
Height: 11 cm
Width: 18 cm

Burrow B
Earthen (Filled In)
Aspect: 300° (NW)
Height: 26 cm
Width: 20 cm

Burrow Site 25: Burrow A

Location: Area 6, DAF #1
Ecoregion: Mojave Desert
Elevation: 1195 m
Topography: Piedmont Slope
Vegetation: *Larrea tridentata/Ambrosia dumosa* Shrubland Association

Burrow A
Earthen (Filled In)
Aspect: 115° (SE)
Height: 12 cm
Width: 20 cm

Burrow Site 26: Burrow A

Location: Area 6, DAF #2
Ecoregion: Mojave Desert
Elevation: 1164 m
Topography: Piedmont Slope
Vegetation: *Larrea tridentata/Ambrosia dumosa* Shrubland Association

Burrow A
Earthen (Filled In)
Aspect: 40° (NE)
Height: 15 cm
Width: 25 cm

Burrow Site 27: Burrow A

Location: Area 5, Cane Spring Road, CS-7 #1
Ecoregion: Mojave Desert
Elevation: 1060 m
Topography: Wash
Vegetation: *Larrea tridentata/Ambrosia dumosa* Shrubland Association

Burrow A
Earthen (Filled In)
Aspect: 240° (SW)
Height: 15 cm
Width: 60 cm

Burrow Site 28: Burrow A

Location: Area 5, Pre-Buggy Pit
Ecoregion: Mojave Desert
Elevation: 969 m
Topography: Basin Floor
Vegetation: *Lycium shockleyi-Lycium pallidum* Shrubland Association

Burrow A
Earthen
Aspect: 5° (N)
Height: 33 cm
Width: 60 cm

Burrow Site 29: Burrow A

Location: Area 5, Cane Spring Road, CS-7 #3
Ecoregion: Mojave
Elevation: 1073 m
Topography: Wash
Vegetation: *Larrea tridentata/Ambrosia dumosa* Shrubland Association

Burrow A
Earthen
Aspect: 20° (N)
Height: 19 cm
Width: 33 cm

Burrow Site 30: Burrows A and B

Location: Area 26, Cane Spring Road, Wash
Ecoregion: Transition
Elevation: 1250 m
Topography: Wash
Vegetation: *Coleogyne ramosissima-Ephedra nevadensis* Shrubland Association

Burrow A
Earthen
Aspect: 230° (SW)
Height: 25 cm
Width: 43 cm

Burrow B
Earthen
Aspect: 240° (SW)
Height: 18 cm
Width: 25 cm

Burrow Site 31: Burrows A and B

Location: Area 5, 5-01 Road, FACE #1
Ecoregion: Mojave Desert
Elevation: 994 m
Topography: Wash
Vegetation: *Atriplex confertifolia-Ambrosia dumosa* Shrubland Association

Burrow A
Earthen
Aspect: 40° (NE)
Height: 17 cm
Width: 23 cm

Burrow B
Earthen
Aspect: 40° (NE)
Height: 16 cm
Width: 40 cm

Burrow Site 32: Burrow A

Location: Area 5, Mercury Highway, M-27
Ecoregion: Mojave Desert
Elevation: 988 m
Topography: Piedmont Slope
Vegetation: *Atriplex confertifolia-Ambrosia dumosa* Shrubland Association

Burrow A
Earthen
Aspect: 20° (N)
Height: 24 cm
Width: 32 cm

Burrow Site 33: Burrow A

Location: Area 5, Mercury Highway, M-16 #1
Ecoregion: Mojave Desert
Elevation: 1109 m
Topography: Wash
Vegetation: *Atriplex confertifolia-Ambrosia dumosa* Shrubland Association

Burrow A
Earthen
Aspect: 280° (W)
Height: 15 cm
Width: 35 cm

Burrow Site 34: Burrows A-E

Location: Area 25, Lathrop Wells Road #1
Ecoregion: Mojave Desert
Elevation: 866 m
Topography: Piedmont Slope
Vegetation: *Larrea tridentata/Ambrosia dumosa* Shrubland Association

Burrow A
Earthen
Aspect: 20° (N)
Height: 15 cm
Width: 18 cm

Burrow B
Earthen
Aspect: 355° (NE)
Height: 8 cm
Width: 20 cm

Burrow C
Earthen
Aspect: 140° (SE)
Height: 18 cm
Width: 15 cm

Burrow D
Earthen
Aspect: 160° (S)
Height: 8 cm
Width: 25 cm

Burrow E
Earthen
Aspect: 280° (W)
Height: 12 cm
Width: 12 cm

Burrow Site 35: Burrow A

Location: Area 22, Jackass Flats Road #2
Ecoregion: Mojave Desert
Elevation: 1073 m
Topography: Wash
Vegetation: *Larrea tridentata/ Ambrosia dumosa* Shrubland Association

Burrow A
Earthen
Aspect: 20° (N)
Height: 25 cm
Width: 50 cm

Burrow Site 36: Burrow A

Location: Area 22, Jackass Flats Road #1
Ecoregion: Mojave Desert
Elevation: 1036 m
Topography: Piedmont Slope
Vegetation: *Menodora spinescens-Ephedra nevadensis* Shrubland Association

Burrow A
Earthen
Aspect: 230° (SW)
Height: 20 cm
Width: 28 cm

Burrow Site 37: Burrow A

Location: Area 18, 18-03 Road #3
Ecoregion: Great Basin Desert
Elevation: 1591 m
Topography: Piedmont Slope
Vegetation: *Artemisia tridentata-Chrysothamnus viscidiflorus* Shrubland Association

Burrow A
Roadcut Earthen
Aspect: 130° (SE)
Height: 15 cm
Width: 45 cm

Burrow Site 38: Burrows A and B

Location: Area 18, Airport Road #2
Ecoregion: Great Basin Desert
Elevation: 1591 m
Topography: Piedmont Slope
Vegetation: *Artemisia tridentata-Chrysothamnus viscidiflorus* Shrubland Association

Burrow A
Roadcut Earthen
Aspect: 280° (W)
Height: 14 cm
Width: 120 cm

Burrow B
Roadcut Earthen
Aspect: 240° (SW)
Height: 20 cm
Width: 60 cm

Burrow Site 39: Burrow A

Location: Area 18, Pahute Mesa Road #1
Ecoregion: Great Basin Desert
Elevation: 1731 m
Topography: Piedmont Slope
Vegetation: *Ephedra nevadensis-Grayia spinosa* Shrubland Association

Burrow A
Roadcut Earthen (Filled In)
Aspect: 130° (SE)
Height: 15 cm
Width: 30 cm

Burrow Site 40: Burrows A and B

Location: Area 16, Pahute Mesa Road #1
Ecoregion: Transition
Elevation: 1511 m
Topography: Piedmont Slope
Vegetation: *Coleogyne ramosissima-Ephedra nevadensis* Shrubland Association

Burrow A
Roadcut Earthen
Aspect: 40° (NE)
Height: 18 cm
Width: 60 cm

Burrow B
Roadcut Earthen
Aspect: 65° (NE)
Height: 10 cm
Width: 27 cm

Burrow Site 41: Burrows A-F

Location: Area 9, 9-01 Road, North of 9G-15 #2, Pad
Ecoregion: Transition
Elevation: 1286 m
Topography: Piedmont Slope
Vegetation: *Ephedra nevadensis-Grayia spinosa* Shrubland Association

Burrows A and B
Culverts
Aspect: 360° (N)
Height: 16 (A), 17 (B) cm
Width: 36 (A, B) cm

Burrow C
Pipe
Aspect: 330° (NW)
Height: 14 cm
Width: 14 cm

Burrows D and E
Culverts
Aspect: 180° (S)
Height: 25 (D), 23 (E) cm
Width: 38 (D), 37 (E) cm

Burrow F
Pipe
Aspect: 150° (SE)
Height: 13 cm
Width: 18 cm

Burrow Site 42: Burrow A

Location: Area 25, Jackass Flats Road #1
Ecoregion: Mojave Desert
Elevation: 1138 m
Topography: Piedmont Slope
Vegetation: *Larrea tridentata/Ambrosia dumosa* Shrubland Association

Burrow A
Earthen (Filled In)
Aspect: 10° (N)
Height: 15 cm
Width: 18 cm

Burrow Site 43: Burrow A

Location: Area 1, Orange Road, O-30 #2, Wash
Ecoregion: Transition
Elevation: 1300 m
Topography: Wash
Vegetation: *Coleogyne ramosissima-Ephedra nevadensis* Shrubland Association

Burrow A
Earthen
Aspect: 220° (SW)
Height: 14 cm
Width: 30 cm

Burrow Site 44: Burrows A-C

Location: Area 5, 5-01 Road, Booster Station #1
Ecoregion: Mojave Desert
Elevation: 1024 m
Topography: Wash
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Earthen
Aspect: 210° (SW)
Height: 10 cm
Width: 23 cm

Burrow B
Earthen
Aspect: 285° (W)
Height: 15 cm
Width: 25 cm

Burrow B
Earthen
Aspect: 310° (NW)
Height: 23 cm
Width: 13 cm

Burrow Site 45: Burrow A

Location: Area 2, 2K Road, Wash
Ecoregion: Transition
Elevation: 1317 m
Topography: Wash
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Earthen
Aspect: 210° (SW)
Height: 20 cm
Width: 43 cm

Burrow Site 46: Burrow A

Location: Area 16, Pahute Mesa Road #2
Ecoregion: Transition
Elevation: 1511 m
Topography: Piedmont Slope
Vegetation: *Ephedra nevadensis-Grayia spinosa* Shrubland Association

Burrow A
Roadcut Earthen
Aspect: 240° (SW)
Height: 12 cm
Width: 60 cm

Burrow Site 47: Burrows A and B

Location: Area 25, Lathrop Wells Road #2
Ecoregion: Mojave Desert
Elevation: 1030 m
Topography: Piedmont Slope
Vegetation: *Larrea tridentata/Ambrosia dumosa* Shrubland Association

Burrow A
Earthen
Aspect: 220° (SW)
Height: 18 cm
Width: 14 cm

Burrow B
Earthen
Aspect: 130° (SE)
Height: 12 cm
Width: 23 cm

Burrow Site 48: Burrows A-C

Location: Area 5, 5-01 Road, Booster Station #2
Ecoregion: Mojave Desert
Elevation: 1018 m
Topography: Wash
Vegetation: *Atriplex confertifolia-Ambrosia dumosa* Shrubland Association

Burrow A
Earthen
Aspect: 60° (NE)
Height: 15 cm
Width: 35 cm

Burrow B
Earthen
Aspect: 90° (E)
Height: 14 cm
Width: 30 cm

Burrow C
Earthen
Aspect: 70° (E)
Height: 15 cm
Width: 30 cm

Burrow Site 49: Burrows A and B

Location: Area 9, 9-01 Road, 2G-24 #4
Ecoregion: Transition
Elevation: 1305 m
Topography: Basin Floor
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Culvert
Aspect: 290° (W)
Height: 27 cm
Width: 35 cm

Burrow B
Culvert
Aspect: 95° (E)
Height: 25 cm
Width: 38 cm

Burrow Site 50: Burrows A and B

Location: Area 5, 5-01 Road, 5A-28
Ecoregion: Mojave Desert
Elevation: 1000 m
Topography: Wash
Vegetation: *Atriplex confertifolia-Ambrosia dumosa* Shrubland Association

Burrow A
Earthen
Aspect: 250° (W)
Height: 15 cm
Width: 25 cm

Burrow B
Earthen (Filled In)
Aspect: 290° (W)
Height: 15 cm
Width: 22 cm

Burrow Site 51: Burrows A-I

Location: Area 2, U-2gg Sump, Pad
Ecoregion: Transition
Elevation: 1317 m
Topography: Basin Floor
Vegetation: Disturbance

Burrow A
Culvert
Aspect: 230° (SW)
Height: 26 cm
Width: 37 cm

Burrow B
Culvert
Aspect: 280° (W)
Height: 24 cm
Width: 38 cm

Burrow C
Culvert
Aspect: 85° (E)
Height: 9 cm
Width: 27 cm

Burrow D
Culvert
Aspect: 200° (S)
Height: 16 cm
Width: 39 cm

Burrow E
Culvert
Aspect: 20° (N)
Height: 21 cm
Width: 36 cm

Burrow Site 51: Burrows A-I (Continued)
Location: Area 2, U-2gg Sump, Pad
Ecoregion: Transition
Elevation: 1317 m
Topography: Basin Floor
Vegetation: Disturbance

Burrow F
Pipe
Aspect: 80° (E)
Height: 16 cm
Width: 15 cm

Burrow G
Pipe
Aspect: 270° (W)
Height: 15 cm
Width: 15 cm

Burrow H
Pipe
Aspect: 0° (N)
Height: 10 cm
Width: 16 cm

Burrow I
Pipe
Aspect: 180° (S)
Height: 15 cm
Width: 15 cm

Burrow Site 52: Burrows A-F
Location: Area 4, 4-04 Road #2, Pad
Ecoregion: Transition
Elevation: 1274 m
Topography: Basin Floor
Vegetation: *Ephedra nevadensis-Grayia spinosa* Shrubland Association

Burrows A & B
Pipes
Aspect: 112° (E)
Height: 14 (A), 15 (B) cm
Width: 14 (A), 17 (B) cm

Burrow C
Culvert
Aspect: 100° (E)
Height: 11 cm
Width: 14 cm

Burrows D & E
Pipes
Aspect: 295° (NW)
Height: 15 (D), 11 (E) cm
Width: 17 (D), 16 (E) cm

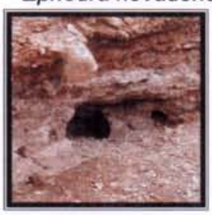
Burrow F
Culvert
Aspect: 270° (W)
Height: 23 cm
Width: 37 cm

Burrow Site 53: Burrows A and B
Location: Area 4, 4-04 Road #3
Ecoregion: Transition
Elevation: 1274 m
Topography: Basin Floor
Vegetation: *Ephedra nevadensis-Grayia spinosa* Shrubland Association

Burrow A
Culvert
Aspect: 80° (E)
Height: 23 cm
Width: 40 cm

Burrow B
Culvert
Aspect: 270° (W)
Height: 23 cm
Width: 38 cm

Burrow Site 54: Burrow A
Location: Area 17, Red Canyon Wash
Ecoregion: Transition
Elevation: 1494 m
Topography: Piedmont Slope
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association



Burrow A
Earthen
Aspect: 60° (NE)
Height: 23 cm
Width: 54 cm

Burrow Site 55: Burrows A-C

Location: Area 5, Cane Spring Road, CS-7 #2
Ecoregion: Mojave Desert
Elevation: 1085 m
Topography: Wash
Vegetation: *Larrea tridentata/Ambrosia dumosa* Shrubland Association

Burrow A
Earthen
Aspect: 120° (SE)
Height: 32 cm
Width: 45 cm

Burrow B
Earthen (Filled In)
Aspect: 320° (NW)
Height: 30 cm
Width: 45 cm

Burrow C
Earthen (Filled In)
Aspect: 230° (SW)
Height: 12 cm
Width: 22 cm

Burrow Site 56: Burrow A

Location: Area 5, Coyote Spring
Ecoregion: Mojave Desert
Elevation: 1109 m
Topography: Piedmont Slope
Vegetation: *Larrea tridentata/ Ambrosia dumosa* Shrubland Association

Burrow A
Earthen
Aspect: 70° (E)
Height: 16 cm
Width: 19 cm

Burrow Site 57: Burrow A

Location: Area 25, Jackass Flats Road #2
Ecoregion: Mojave Desert
Elevation: 1115 m
Topography: Piedmont Slope
Vegetation: *Larrea tridentata/ Ambrosia dumosa* Shrubland Association

Burrow A
Earthen (Filled In)
Aspect: 225° (SW)
Height: Unknown
Width: Unknown

Burrow Site 58: Burrows A and B

Location: Area 8, 8D Road, North of 8D-2
Ecoregion: Transition
Elevation: 1384 m
Topography: Piedmont Slope
Vegetation: Disturbance

Burrow A
Culvert
Aspect: 260° (W)
Height: 21 cm
Width: 38 cm

Burrow B
Culvert
Aspect: 70° (E)
Height: 9 cm
Width: 21 cm

Burrow Site 59: Burrows A and B

Location: Area 8, 8D Road, 8D-2 #1
Ecoregion: Transition
Elevation: 1378 m
Topography: Piedmont Slope
Vegetation: Disturbance

Burrow A
Culvert
Aspect: 270° (W)
Height: 19 cm
Width: 30 cm

Burrow B
Culvert
Aspect: 90° (E)
Height: 21 cm
Width: 37 cm

Burrow Site 60: Burrows A and B

Location: Area 4, 4-04 Road #4
Ecoregion: Transition
Elevation: 1281 m
Topography: Basin Floor
Vegetation: *Krascheninnikovia lanata-Ephedra nevadensis* Shrubland Association

Burrow A
Culvert
Aspect: 355° (NE)
Height: 18 cm
Width: 35 cm

Burrow B
Culvert
Aspect: 180° (S)
Height: 30 cm
Width: 34 cm

Burrow Site 61: Burrow A

Location: Area 18, Old Buckboard Mesa Road
Ecoregion: Great Basin Desert
Elevation: 1518 m
Topography: Wash
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Earthen (Filled In)
Aspect: 220° (SW)
Height: 15 cm
Width: 47 cm

Burrow Site 62: Burrow A

Location: Area 5, 5-01 Road, FACE #2
Ecoregion: Mojave Desert
Elevation: 1000 m
Topography: Wash
Vegetation: *Atriplex confertifolia-Ambrosia dumosa* Shrubland Association

Burrow A
Earthen
Aspect: 340° (NE)
Height: 14 cm
Width: 65 cm

Burrow Site 63: Burrows A-C

Location: Area 2, 2E and 2K Roads Intersection
Ecoregion: Transition
Elevation: 1313 m
Topography: Basin Floor
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Culvert
Aspect: 340° (NE)
Height: 18 cm
Width: 36 cm

Burrow B
Culvert
Aspect: 150° (SE)
Height: 12 cm
Width: 23 cm

Burrow C
Culvert
Aspect: 355° (NE)
Height: 23 cm
Width: 35 cm

Burrow Site 64: Burrows A-K

Location: Area 8, 8D Road, Pad
Ecoregion: Transition
Elevation: 1384 m
Topography: Piedmont Slope
Vegetation: Disturbance

Burrow A
Culvert
Aspect: 340° (NE)
Height: 27 cm
Width: 39 cm

Burrow B
Culvert
Aspect: 150° (SE)
Height: 19 cm
Width: 44 cm

Burrow C
Pipe
Aspect: 190° (S)
Height: 14 cm
Width: 14 cm

Burrow D
Pipe
Aspect: 10° (N)
Height: 17 cm
Width: 17 cm

Burrow E
Culvert
Aspect: 30° (NE)
Height: 26 cm
Width: 38 cm

Burrow Site 64: Burrows A-K (Continued)
Location: Area 8, 8D Road, Pad
Ecoregion: Transition
Elevation: 1384 m
Topography: Piedmont Slope
Vegetation: Disturbance


Burrow F
Culvert
Aspect: 200° (S)
Height: 31 cm
Width: 48 cm


Burrow G
Culvert
Aspect: 340° (NE)
Height: 15 cm
Width: 43 cm


Burrow H
Culvert
Aspect: 50° (NE)
Height: 28 cm
Width: 34 cm


Burrow I
Culvert
Aspect: 240° (SW)
Height: 23 cm
Width: 37 cm


Burrow J
Pipe
Aspect: 300° (NW)
Height: 15 cm
Width: 15 cm

Burrow Site 64: Burrows A-K (Continued)
Location: Area 8, 8D Road, Pad
Ecoregion: Transition
Elevation: 1384 m
Topography: Piedmont Slope
Vegetation: Disturbance


Burrow K
Pipe
Aspect: 120° (SE)
Height: 17 cm
Width: 17 cm

Burrow Site 65: Burrows A and B
Location: Area 5, 5-01 Road, FACE #3
Ecoregion: Mojave Desert
Elevation: 1006 m
Topography: Hilltop
Vegetation: *Larrea tridentata/ Ambrosia dumosa* Shrubland Association


Burrow A
Earthen
Aspect: 240° (SW)
Height: 18 cm
Width: 31 cm


Burrow B
Earthen
Aspect: 80° (E)
Height: 22 cm
Width: 25 cm

Burrow Site 66: Burrow A
Location: Area 9, 9-01 Road and Old Mercury Highway Intersection
Ecoregion: Transition
Elevation: 1280 m
Topography: Piedmont Slope
Vegetation: *Ephedra nevadensis-Grayia spinosa* Shrubland Association


Burrow A
Culvert
Aspect: 350° (NE)
Height: 15 cm
Width: 36 cm

Burrow Site 67: Burrows A-E
Location: Area 2, 2-07 Road, 2L-18 Pad
Ecoregion: Transition
Elevation: 1329 m
Topography: Piedmont Slope
Vegetation: Disturbance

Burrow A
Culvert
Aspect: 360° (S)
Height: 22 cm
Width: 38 cm

Burrow B
Culvert
Aspect: 180° (S)
Height: 17 cm
Width: 37 cm

Burrow C
Pipe
Aspect: 360° (S)
Height: 16 cm
Width: 16 cm

Burrow D
Pipe
Aspect: 180° (S)
Height: 15 cm
Width: 15 cm

Burrow E
Culvert
Aspect: 360° (N)
Height: 26 cm
Width: 37 cm

Burrow Site 68: Burrow A
Location: Area 18, Airport Road #3
Ecoregion: Great Basin Desert
Elevation: 1543 m
Topography: Piedmont Slope
Vegetation: Disturbance

Burrow A
Roadcut Earthen
Aspect: 100° (E)
Height: 10 cm
Width: 30 cm

Burrow Site 69: Burrows A and B
Location: Area 4, 4-04 Road #5
Ecoregion: Transition
Elevation: 1323 m
Topography: Piedmont Slope
Vegetation: *Hymenoclea salsola-Ephedra nevadensis* Shrubland Association

Burrow A
Roadcut Earthen (Filled In)
Aspect: 350° (NE)
Height: 18 cm
Width: 20 cm

Burrow B
Earthen (Inaccessible Area; Southern perspective photo)
Aspect: 170° (S)
Height: Unknown
Width: Unknown

Burrow Site 70: Burrows A and B
Location: Area 20, U-20bb Pad
Ecoregion: Great Basin Desert
Elevation: 1902 m
Topography: Mesa Steepe
Vegetation: *Artemisia tridentata-Chrysothamnus viscidiflorus* Shrubland Association

Burrow A
Culvert
Aspect: 130° (E)
Height: 18 cm
Width: 34 cm

Burrow B
Culvert
Aspect: 130° (E)
Height: 27 cm
Width: 37 cm

Burrow Site 71: Burrow A
Location: Area 5, Mercury Highway, M-16 #2
Ecoregion: Mojave Desert
Elevation: 1098 m
Topography: Piedmont Slope
Vegetation: *Coleogyne ramosissima-Ephedra nevadensis* Shrubland Association

Burrow A
Earthen
Aspect: 350° (NE)
Height: 16 cm
Width: 32 cm

Burrow Site 72: Burrow A

Location: Area 5, RWMS Expansion Area
Ecoregion: Mojave Desert
Elevation: 988 m
Topography: Piedmont Slope
Vegetation: *Larrea tridentata/ Ambrosia dumosa* Shrubland Association

Unavailable

Burrow A
Earthen (Crushed)
Aspect: Unknown
Height: Unknown
Width: Unknown

Burrow Site 73: Burrows A and B

Location: Area 9, 9-01 Road, 9G-11
Ecoregion: Transition
Elevation: 1323 m
Topography: Piedmont Slope
Vegetation: Disturbance

Burrow A
Culvert
Aspect: 110° (E)
Height: 7 cm
Width: 33 cm

Burrow B
Culvert
Aspect: 290° (W)
Height: 11 cm
Width: 25 cm

Burrow Site 74: Burrow A

Location: Area 5, RWMS South Gate
Ecoregion: Mojave Desert
Elevation: 970 m
Topography: Piedmont Slope
Vegetation: *Larrea tridentata/ Ambrosia dumosa* Shrubland Association

Burrow A
Pipe
Aspect: 90° (E)
Height: 9 cm
Width: 20 cm

Burrow Site 75: Burrow A

Location: Area 2, U-2ge
Ecoregion: Transition
Elevation: 1326 m
Topography: Basin Floor
Vegetation: Disturbance

Unavailable

Burrow A
Pipe (Filled In)
Aspect: 70° (E)
Height: 20 cm
Width: 20 cm

Burrow Site 76: Burrows A-C

Location: Area 8, 8D Road, 8D-2 #2
Ecoregion: Transition
Elevation: 1378 m
Topography: Piedmont Slope
Vegetation: *Coleogyne ramosissima-Ephedra nevadensis* Shrubland Association

Burrow A
Culvert
Aspect: 120° (SE)
Height: 15 cm
Width: 30 cm

Burrow B
Pipe
Aspect: 280° (W)
Height: 17 cm
Width: 17 cm

Burrow C
Pipe
Aspect: 110° (E)
Height: 13 cm
Width: 15 cm

Burrow Site 77: Burrow A

Location: Area 20, U-20bb Road
Ecoregion: Great Basin Desert
Elevation: 1905 m
Topography: Piedmont Slope
Vegetation: Disturbance

Burrow A
Culvert
Aspect: 10° (N)
Height: 22 cm
Width: 37 cm

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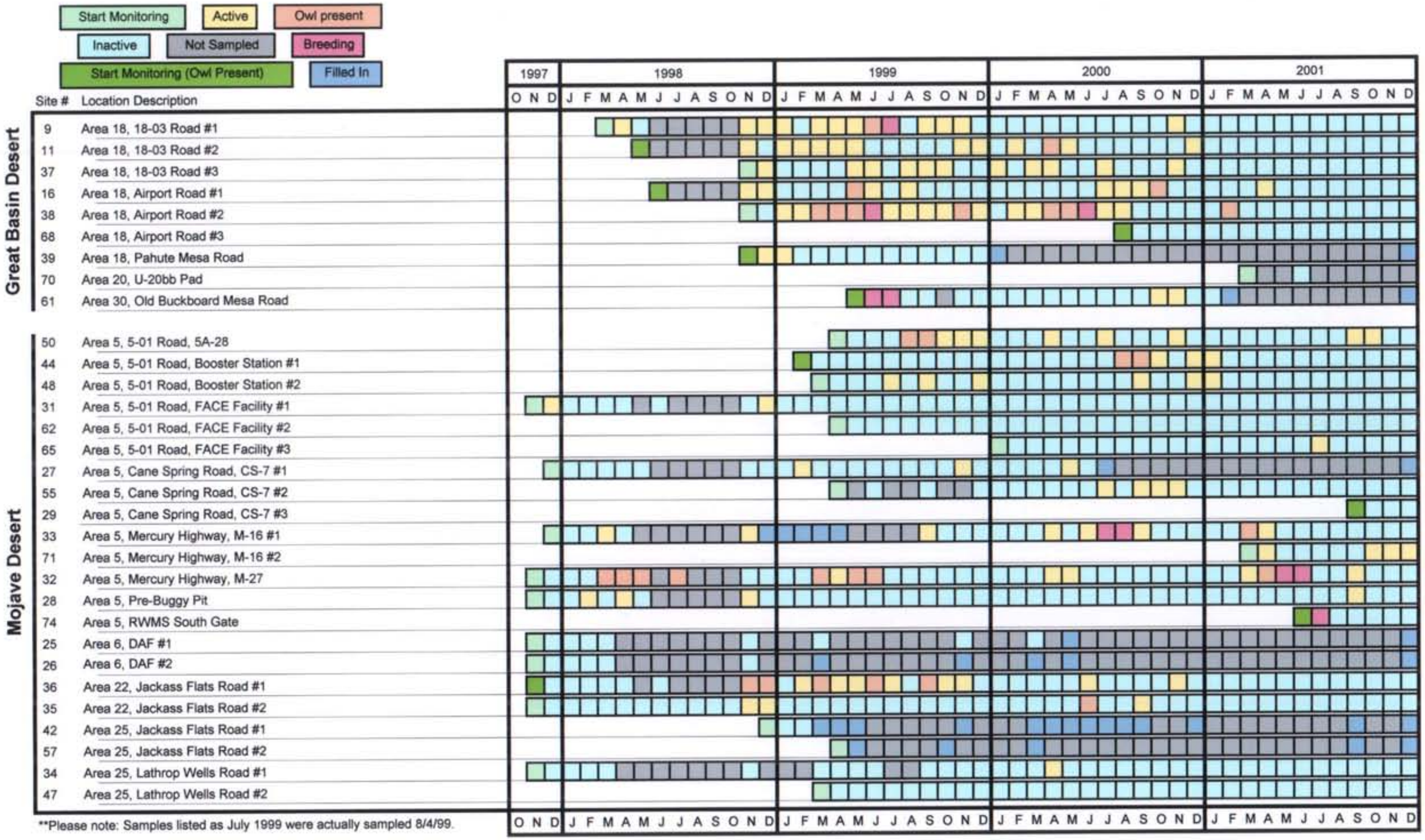
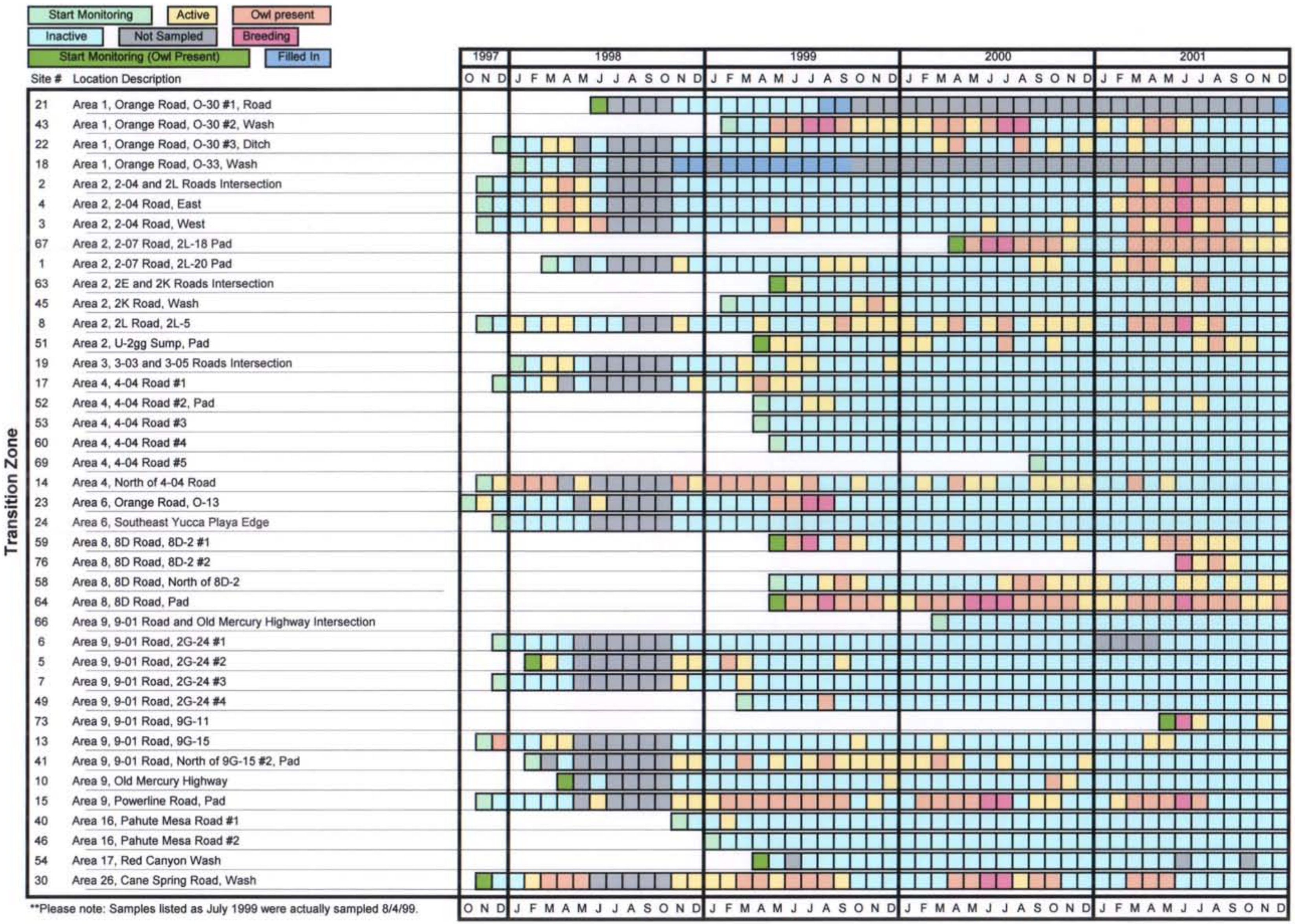


**Please note: Samples listed as July 1999 were actually sampled 8/4/99.



**Please note: Samples listed as July 1999 were actually sampled 8/4/99.

Appendix C

Burrow Use Rates by Burrow Site (BURS) Including the Number of Months a Burrow Site was Monitored and the Number of Months Fresh Sign was Detected from November 1997 to December 2001 (n=56; only includes active burrows monitored for at least seven months).

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Site Description (Burrow Site Number)	Burrow Type[a]	Number of Months		BURS
		Detected A	Monitored B	A/B x 100
Great Basin Desert ecoregion				
Area 18, 18-03 Road #1 (#9)	EM	14	41	34.1
Area 18, 18-03 Road #2 (#11)	EM	13	39	33.3
Area 18, 18-03 Road #3 (#37)	EM	12	38	31.6
Area 18, Airport Road #1 (#16)	EM	11	39	28.2
Area 18, Airport Road #2 (#38)	EM	21	38	55.3
Area 18, Airport Road #3 (#68)	EM	1	17	5.9
Area 18, Pahute Mesa Road (#39)	EM	3	15	20.0
Area 30, Old Buckboard Mesa Road (#61)	EN	5	21	23.8
Average % use rate				**29.0**
Mojave Desert ecoregion				
Area 5, 5-01 Road, 5A-28 (# 50)	EN	11	33	33.3
Area 5, 5-01 Road, Booster Station #1 (# 44)	EN	6	35	17.1
Area 5, 5-01 Road, Booster Station #2 (# 48)	EN	7	34	20.6
Area 5, 5-01 Road, FACE #1 (# 31)	EN	3	45	6.7
Area 5, 5-01 Road, FACE #3 (# 65)	EN	2	24	8.3
Area 5, Cane Spring Road, CS-7 #1 (#27)	EN	4	27	14.8
Area 5, Cane Spring Road, CS-7 #2 (#55)	EN	5	28	17.9
Area 5, Mercury Highway, M-16 #1 (# 33)	EN	11	35	31.4
Area 5, Mercury Highway, M-16 #2 (# 71)	EN	5	10	50.0
Area 5, Mercury Highway, M-27 (# 32)	EM	16	46	34.8
Area 5, Pre-Buggy Pit (# 28)	EM	4	45	8.9
Area 5, RWMS South Gate (# 74)	P	2	7	28.6
Area 22, Jackass Flats Road #1 (# 36)	EN	14	45	31.1
Area 22, Jackass Flats Road #2 (# 35)	EN	5	50	10.0
Area 25, Lathrop Wells Road #1 (# 34)	EN	2	38	5.3
Average % use rate				**21.3**

[a]EM=Earthen burrow in man-altered habitat; EN=Earthen burrow in natural habitat; C=Culvert burrow; CP=Culvert and pipe burrow; P=Pipe burrow

Site Description	Burrow Type[a]	Number of Months		BURS
Transition ecoregion		**Detected A**	**Monitored B**	**A/B x 100**
Area 1, Orange Road, O-30 #1, Road (# 21)	EM	1	11	9.1
Area 1, Orange Road, O-30 #2, Wash (# 43)	EN	22	35	62.9
Area 1, Orange Road, O-30 #3, Ditch (# 22)	EM	10	44	22.7
Area 2, 2-04 and 2L Roads Intersection (# 2)	C	10	46	21.7
Area 2, 2-04 Road, East (# 4)	C	15	46	32.6
Area 2, 2-04 Road, West (# 3)	C	16	46	34.7
Area 2, 2-07 Road, 2L-18 Pad (# 67)	CP	18	21	85.7
Area 2, 2-07 Road, 2L-20 Pad (# 1)	CP	11	41	26.8
Area 2, 2E and 2K Roads Intersection (# 63)	C	4	32	12.5
Area 2, 2K Road, Wash (# 45)	EN	4	35	11.4
Area 2, 2L Road, 2L-5 (# 8)	C	26	47	55.3
Area 2, U-2gg Sump, Pad (# 51)	CP	11	33	33.3
Area 3, 3-03 and 3-05 Roads Intersection (# 19)	P	7	43	16.3
Area 4, 4-04 Road #1 (# 17)	C	7	43	16.3
Area 4, 4-04 Road #2, Pad (# 52)	CP	5	33	15.2
Area 4, 4-04 Road #3 (# 53)	C	1	33	3.0
Area 4, North of 4-04 Road (# 14)	C	26	44	59.1
Area 6, Orange Road, O-13 (# 23)	EM	7	46	15.2
Area 8, 8D Road, 8D-2 #1 (# 59)	C	13	32	40.6
Area 8, 8D Road, 8D-2 #2 (# 76)	CP	4	7	57.1
Area 8, 8D Road, North of 8D-2 (# 58)	C	16	32	50.0
Area 8, 8D Road, Pad (# 64)	CP	32	32	100.0
Area 9, 9-01 Road, 2G-24 #2 (# 5)	C	7	41	17.1
Area 9, 9-01 Road, 2G-24 #3 (# 7)	C	3	43	7.0
Area 9, 9-01 Road, 2G-24 #4 (# 49)	C	2	34	5.9
Area 9, 9-01 Road, 9G-11 (# 73)	C	4	8	50.0
Area 9, 9-01 Road, 9G-15 (# 13)	C	8	44	18.2
Area 9, 9-01 Road, North of 9G-15 #2, Pad (# 41)	CP	17	40	42.5
Area 9, Old Mercury Highway (# 10)	C	4	40	10.0
Area 9, Powerline Road, Pad (# 15)	C	28	45	62.2
Area 16, Pahute Mesa Road #1 (# 40)	EM	2	38	5.3
Area 17, Red Canyon Wash (# 54)	EN	1	30	3.3
Area 26, Cane Spring Road, Wash (# 30)	EN	26	45	57.8
Average % use rate				**32.1**
Entire NTS				**28.8**

[a]EM=Earthen burrow in man-altered habitat; EN=Earthen burrow in natural habitat; C=Culvert burrow; CP=Culvert and pipe burrow; P=Pipe burrow

Appendix D

Monthly Owl Burrow Use Summary Data Set by Ecoregion, November 1997 through December 2001.

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	Great Basin Desert			Mojave Desert			Transition		
Date	No. Active Burrows	No. Burrows Sampled	Percent Active Burrows	No. Active Burrows	No. Burrows Sampled	Percent Active Burrows	No. Active Burrows	No. Burrows Sampled	Percent Active Burrows
Nov-97	0	0	0	3	8	38	5	9	56
Dec-97	0	0	0	1	10	10	2	14	14
Jan-98	0	0	0	0	10	0	2	16	13
Feb-98	0	0	0	1	10	10	4	19	21
Mar-98	1	1	100	2	10	20	11	19	58
Apr-98	1	1	100	2	7	29	9	18	50
May-98	1	2	50	1	3	33	5	9	56
Jun-98	1	1	100	0	2	0	4	11	36
Nov-98	6	6	100	4	10	40	9	22	41
Dec-98	4	6	67	3	8	38	6	21	29
Jan-99	4	6	67	0	7	0	4	22	18
Feb-99	2	6	33	3	8	38	6	24	25
Mar-99	3	6	50	3	13	23	9	25	36
Apr-99	3	6	50	3	15	20	9	29	31
May-99	6	7	86	2	12	17	13	34	38
Jun-99	5	7	71	2	13	15	12	33	36
Jul-99	3	7	43	2	11	18	10	34	29
Aug-99	3	7	43	1	11	9	11	34	32
Sep-99	3	7	43	4	14	29	10	33	30
Oct-99	3	6	50	2	13	15	10	33	30
Nov-99	3	7	43	3	14	21	6	33	18
Dec-99	2	7	29	2	14	14	7	33	21
Jan-00	1	7	14	1	15	7	5	33	15
Feb-00	2	6	33	0	15	0	6	33	18
Mar-00	2	6	33	0	16	0	7	34	21
Apr-00	3	6	50	4	15	27	10	35	29
May-00	2	6	33	2	16	13	6	35	17
Jun-00	1	6	17	3	15	20	8	34	24
Jul-00	3	6	50	3	15	20	9	35	26
Aug-00	3	7	43	2	14	14	6	35	17
Sep-00	1	7	14	5	14	36	9	36	25
Oct-00	2	7	29	2	14	14	11	36	31
Nov-00	3	7	43	3	14	21	8	36	22
Dec-00	1	7	14	2	14	14	6	36	17
Jan-01	0	7	0	2	14	14	3	35	9
Feb-01	1	7	14	0	14	0	4	35	11
Mar-01	0	6	0	3	15	20	12	35	34
Apr-01	1	6	17	3	15	20	13	35	37
May-01	0	6	0	1	15	7	12	37	32
Jun-01	0	7	0	2	16	13	13	37	35
Jul-01	0	6	0	0	16	0	14	38	37
Aug-01	0	6	0	0	16	0	6	38	16
Sep-01	0	6	0	4	17	24	7	38	18
Oct-01	0	6	0	2	17	12	4	37	11
Nov-01	0	6	0	1	17	6	5	38	13
Dec-01	0	6	0	1	17	6	5	38	13

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Appendix E

TrailMaster® Camera System Results by Ecoregion and Burrow for the Breeding Seasons of 1999-2001.

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GREAT BASIN DESERT ECOREGION

<u>Area 18, 18-03 Road #1 (#9)</u>
Burrow A
7/16-7/19/99—1 owl
Burrow B
6/24-6/26/99—2 adult owls
7/23-7/27/99—1 young owl

<u>Area 18, 18-03 Road #2 (#11)</u>
Burrow A
6/5-6/8/00—Woodrat; antelope ground squirrel; desert cottontail rabbit; black-tailed jackrabbit

<u>Area 18, 18-03 Road #3 (#37)</u>
4/10-4/12/00—Passerine; 2 ravens
7/31-8/2/00—Badger; desert cottontail rabbit

<u>Area 18, Airport Road #1 (#16)</u>
7/31-8/2/00—Nothing
4/25-4/27/01—Woodrat; rodent

<u>Area 18, Airport Road #2 (#38)</u>
Burrow A
5/22-5/25/00—1 owl; woodrat
6/22-6/26/00—4 young owls (camera shifted to north)
7/28-7/31/00—Desert cottontail rabbit; antelope ground squirrel
Burrow B
6/26-6/29/99—3 young
4/10-4/12/00—2 adult owls
5/22-5/25/00—2 adult owls; unknown animal; prey items
6/22-6/26/00—8 young owls
7/28-7/31/00—Desert cottontail rabbit

<u>Area 30, Old Buckboard Mesa Road (#61)</u>
6/29-7/1/99—6 young owls

MOJAVE DESERT ECOREGION

<u>Area 5, 5-01 Road, 5A-28 (#50)</u>
4/24-4/26/00—Nothing
8/4-8/7/00—Nothing

<u>Area 5, 5-01 Road, Booster Station #2 (#48)</u>
Burrow A
8/19-8/24/99--Nothing

Area 5, Cane Spring Road, CS-7 #1 (#27)
5/25-6/1/00—Antelope ground squirrel

Area 5, Mercury Highway, M-16 #1 (#33)
4/24-4/26/00—Nothing
7/3-7/6/00—3 young owls
8/4-8/7/00—3 young owls (camera problems; only 5 pictures)
5/25-5/29/01—1 kit fox

Area 5, Mercury Highway, M-16 #2 (#71)
5/25-5/29/01—Nothing

Area 5, Mercury Highway, M-27 (#32)
6/7-6/11/99—1 adult owl
4/17-4/19/00—Nothing
5/25-6/1/00—Nothing
4/27-4/30/01—2 adult owls
5/31-6/4/01—3 young owls; 1 adult owl with prey
8/13-8/15/01—Nothing

Area 5, RWMS South Gate (#74)
6/29-7/3/01—4 owls (at least 3 young)
8/13-8/15/01—Nothing

Area 22, Jackass Flats Road #1 (#36)
6/11-6/14/99—1 adult owl (camera tilted)
8/24-9/9/99—Nothing
6/29-7/3/00—Nothing

Area 22, Jackass Flats Road #2 (#35)
6/29-7/3/00—Antelope ground squirrel; unidentified animal; (cable cut)

Area 25, Lathrop Wells Road #1 (#34)
Burrow B
4/26-5/1/00—2 kit foxes

TRANSITION ECOREGION

Area 1, Orange Road, O-30 #2, Wash (#43)
7/7-7/10/99—Nothing
7/30-8/4/99—3 young owls (camera tilted, low battery 7/30-8/2)
4/12-4/14/00—2 adult owls (camera tilted)
6/2-6/5/00—2 adult owls
7/3-7/6/00—5 young owls
8/2-8/4/00—2 owls (at least 1 young); desert cottontail rabbit; transmitter tipped over
8/7-8/10/00—3 owls (at least 1 young); desert cottontail rabbit

4/25-4/27/01—2 adult owls (non-breeding pair); desert cottontail rabbit
5/31-6/4/01—1 adult owl (only 3 pictures, camera problems)
6/15-6/18/01—Antelope ground squirrel; badger; 2 desert cottontail rabbits (1 adult, 1 juvenile); (Low battery on receiver, 15 pictures)

Area 1, Orange Road, O-30 #3, Ditch (#22)
Burrow A
4/12-4/14/00—Desert cottontail rabbit
Burrow B
4/26-5/1/00—2 adult owls (Non-breeding pair)

Area 2, 2-04 and 2L Roads Intersection (#2)
Burrow A
5/18-5/21/01—2 adult owls (1 with prey)
6/20-6/22/01—1 young owl; 2 adult owls
7/30-8/1/01—3 owls; woodrat; desert cottontail rabbit
Burrow B
5/18-5/21/01—2 adult owls
6/20-6/22/01—2 adult owls; at least 1 young owl; black-tailed jackrabbit
7/30-8/1/01—2 owls; antelope ground squirrel; woodrat?

Area 2, 2-04 Road, East (#4)
Burrows A and B
5/21-5/23/01—2 adult owls
6/25-6/27/01—5 owls (at least 4 young)
8/3-8/6/01—4 owls; desert cottontail rabbit
Burrows C, D, and E
5/21-5/23/01—1 adult owl; black-tailed jackrabbit
6/25-6/27/01—6 owls (2 adults, 4 young); desert cottontail rabbit
8/3-8/6/01—1 owl; black-tailed jackrabbit; desert cottontail rabbit

Area 2, 2-04 Road, West (#3)
Burrow A
7/14-7/16/99—Nothing
6/12-6/15/00—Film split in two no pictures
6/19-6/22/00—Desert cottontail rabbit; black-tailed jackrabbit
5/14-5/16/01—1 adult owl; black-tailed jackrabbit; desert cottontail rabbit
6/22-6/25/01—4 young owls; black-tailed jackrabbit
8/1-8/3/01—1 adult owl; desert cottontail rabbit; black-tailed jackrabbit
Burrow B
5/14-5/16/01--2 adult owls; desert cottontail rabbit
6/22-6/25/01—1 adult owl, 1 young owl (cable cut, camera tilted down, only 5 pictures)
8/1-8/3/01—1 adult owl; desert cottontail rabbit

Area 2, 2-07 Road, 2L-18 Pad (#67)

Burrows A and C

4/6-4/10/00—2 adult owls
5/11-5/15/00—2 adult owls (camera tilted)
5/15-5/18/00—1 owl; Hawk?
6/26-6/29/00—7 owls (at least 5 young; transmitter or receiver knocked over)
7/10-7/13/00—5 young owls
7/17-7/19/00—1 owl (Camera problems; only 2 pictures)
5/7-5/9/01—1 adult owl
6/11-6/13/01—2 adult owls (Non-breeding pair)
7/23-7/25/01—2 owls

Burrows B and D

7/17-7/19/00—6 owls (at least 4 young inferred)
5/7-5/9/01—unknown
6/11-6/13/01—2 adult owls
7/23-7/25/01—2 owls (1 adult, 1 juvenile); Not a breeding burrow, too late in season and no juveniles detected before this

Burrow E

6/26-6/29/00—2 owls (transmitter or receiver knocked over; only 7 pictures)
7/10-7/13/00—2 young owls; antelope ground squirrel
6/29-7/3/01—Desert cottontail rabbit; black-tailed jackrabbit
7/25-7/27/01—Desert cottontail rabbit; kangaroo rat

Area 2, 2-07 Road, 2L-20 Pad (#1)

Burrow A

5/9-5/11/01—Black-tailed jackrabbit; desert cottontail rabbit

Burrow B

5/11-5/13/01—Black-tailed jackrabbit; antelope ground squirrel

Burrow C

5/9-5/11/01—Kangaroo rat; black-tailed jackrabbit; desert cottontail rabbit

Burrow E

5/11-5/13/01—Kangaroo rat; black-tailed jackrabbit; desert cottontail rabbit

Area 2, 2E and 2K Roads Intersection (#63)

Burrow A

7/5-7/9/01—1 young owl; 1 adult owl with prey; antelope ground squirrel; kangaroo rat; raven; Not a breeding burrow, no sign detected before this
8/8-8/13/01—Nothing

Burrow B

7/12-7/14/99—Nothing
7/5-7/9/01—2 adult owls; raven
8/8-8/13/01—Antelope ground squirrel; desert cottontail rabbit

Area 2, 2L Road, 2L-5 (#8)

Burrow A

4/14-4/17/00—1 owl; black-tailed jackrabbit

7/19-7/21/00—4 owls (at least 2 young inferred); black-tailed jackrabbit; Not a breeding burrow
5/16-5/18/01—2 adult owls
6/27-6/29/01—8 owls (1 adult, 7 young)
8/6-8/8/01—2 owls
Burrow C
6/5-6/8/00—Nothing
7/19-7/21/00—1 owl; antelope ground squirrel; desert cottontail rabbit
5/16-5/18/01—1 adult owl with prey; antelope ground squirrel; black-tailed jackrabbit; desert cottontail rabbit
6/27-6/29/01—3 juvenile owls; raven
8/6-8/8/01—2 owls; desert cottontail rabbit

Area 2, U-2gg Sump, Pad (#51)
Burrow A
8/15-8/20/01—1 owl; desert cottontail rabbit
Burrow B
8/15-8/20/01—Desert cottontail rabbit
Burrow F
8/2-8/4/00—Badger; kit fox; antelope ground squirrel

Area 3, 3-03 and 3-05 Roads Intersection (# 19)
Burrows A and B
7/10-7/12/99—Desert cottontail rabbit
8/9-8/17/99—Desert cottontail rabbit (camera tilted)

Area 4, 4-04 Road #2, Pad (#52)
Burrow F
8/9-8/11/99—Desert cottontail rabbit

Area 4, North of 4-04 Road (#14)
Burrow A
6/22-6/24/99—Nothing
8/6-8/9/99—Nothing
4/14-4/17/00— 2 adult owls (Non-breeding pair)
6/1-6/5/00—Antelope ground squirrel; kangaroo rat
4/27-4/30/01—No owls; kangaroo rat; antelope ground squirrel; black-tailed jackrabbit; unknown animal

Area 6, Orange Road, O-13 (#23)
7/1-7/7/99—Nothing
7/30-8/6/99—3 young owls (7/30-8/2—camera tilted)

Area 8, 8D Road, 8D-2 #1 (#59)
Burrow B (East)
6/16-6/19/99—2 adult owls
7/26-7/28/99—3 young owls

4/17-4/19/00—1 owl; desert cottontail rabbit
5/4-5/7/01—Desert cottontail rabbit; black-tailed jackrabbit
Burrow A (West)
5/4-5/7/01--1 owl; 2 desert cottontail rabbits; black-tailed jackrabbit; antelope ground squirrel
6/13-6/15/01—1 owl; 3 desert cottontail rabbits; black-tailed jackrabbit; 2 birds; rodent
7/18-7/20/01—Rodent; desert cottontail rabbit

<u>Area 8, 8D Road, 8D-2 #2 (#76)</u>
Burrow A
6/13-6/15/01—9 owls (8 young, 1 adult)
7/18-7/20/01—Black-tailed jackrabbit

<u>Area 8, 8D Road, North of 8D-2 (#58)</u>
Burrow A (West)
7/26-7/28/00—6 owls (at least 4 young inferred); black-tailed jackrabbit
7/20-7/23/01—Desert cottontail rabbit; antelope ground squirrel; rodent
Burrow B (East)
7/20-7/23/01—Desert cottontail rabbit; rodent

<u>Area 8, 8D Road, Pad (#64)</u>
Burrow A
6/19-6/22/99—2 adult owls
8/4-8/6/99—5 young owls
7/26-7/28/00—4 owls (at least 2 young owls inferred)
4/30-5/2/01—1 adult owl with prey
6/4-6/6/01—7 owls (6 young, 1 adult)
7/9-7/11/01—1 adult owl; cottontail rabbit
Burrow B
7/28-7/30/99—Nothing
2/22-3/22/00—2 adult owls on 3/8
4/4-4/6/00—2 adult owls
5/18-5/22/00—4 young owls
6/16-6/19/00—4 young owls
7/24-7/26/00—2 owls (at least 1 young); desert cottontail rabbit; black-tailed jackrabbit
4/30-5/2/01—2 adult owls
6/4-6/6/01—6 young owls; black-tailed jackrabbit
7/9-7/11/01—1 owl; antelope ground squirrel; desert cottontail rabbit (camera tilted)
Burrow C
6/6-6/8/01—4 owls (at least 2 young); 2 desert cottontail rabbits
7/11-7/13/01—Coyote; antelope ground squirrel; desert cottontail rabbit ; black-tailed jackrabbit
Burrow D
6/6-6/8/01—1 owl
7/11-7/13/01—Antelope ground squirrel
Burrow E
5/18-5/22/00—2 adult owls
6/16-6/19/00—7 young owls

7/24-7/26/00—Antelope ground squirrel; desert cottontail rabbit
5/2-5/4/01—2 adult owls
6/8-6/11/01—6 young owls
7/13-7/16/01—Desert cottontail rabbit
Burrow F
5/2-5/4/01—1 adult owl; rodent
6/8-6/11/01—3 owls
7/13-7/16/01—Bobcat; antelope ground squirrel; black-tailed jackrabbit; desert cottontail rabbit; coyote; kangaroo rat
Burrow J
7/16-7/18/01—Desert cottontail rabbit
Burrow K
7/16-7/18/01—Kit fox with rabbit

Area 9, 9-01 Road, 9G-11 #73
Burrow A (East)
6/18-6/20/01—7 owls (at least 6 young; feeding frenzy)
7/27-7/30/01--Nothing
Burrow B (West)
6/18-6/20/01—8 owls (at least 7 young)
7/27-7/30/01—kangaroo rat; desert cottontail rabbit; antelope ground squirrel

Area 9, 9-01 Road, 9G-15 (#13)
5/23-5/25/01—Nothing

Area 9, 9-01 Road, North of 9G-15 #2, Pad (#41)
Burrows A and B
8/6-8/9/99—1 adult owl; black-tailed jackrabbit
Burrows D and E
4/6-4/10/00—Rodent
7/21-7/24/00—Nothing (Camera cable cut and transmitter and receiver knocked over; only a few pictures)

Area 9, Powerline Road, Pad (#15)
6/14-6/16/99—2 adult owls
7/27-7/30/99—2 adult owls
8/11-8/17/99—2 adult owls (Non-breeding pair)
8/24-9/9/99—2 adult owls (transmitter dead?)
2/22-3/8/00—1 owl
3/8-3/22/00—1 owl (camera did not work 3/13-3/22)
3/22-3/25/00—2 adult owls
4/4-4/6/00—2 adult owls
5/11-5/15/00—2 adult owls (transmitter knocked over and other problems; 21 pictures)
5/15-5/18/00—2 adult owls
6/19-6/22/00—5 young owls
7/21-7/24/00—1 young owl

5/23-5/25/01—2 adult owls
6/15-6/18/01—7 owls (at least 6 young)
7/25-7/27/01—Desert cottontail rabbit

Area 26, Cane Spring Road, Wash (#30)
Burrow A (West)
6/3-6/4/99—Nothing
7/19-7/21/99—Badger (transmitter moved)
8/17-8/19/99—Nothing
4/19-4/24/00—2 adult owls
6/8-6/12/00—1 owl; 2 desert cottontail rabbits; antelope ground squirrel; black-tailed jackrabbit; cable cut and low battery on receiver
7/6-7/10/00—1 adult owl and 4 young owls; cable cut and exposed film (only 13 pictures)
7/13-7/17/00—5 owls (at least 3 young inferred); 2 desert cottontail rabbits; cable cut (only 17 pictures)
5/29-5/31/01—woodrat; desert cottontail rabbit; kangaroo rat
7/3-7/5/01—woodrat?
Burrow B (East)
6/4-6/7/99—Nothing
7/21-7/23/99—Nothing
8/17-8/24/99—2 adult owls
4/19-4/24/00—2 adult owls; desert cottontail rabbit
6/8-6/12/00—6 young owls
7/6-7/10/00—1 young owl
7/13-7/17/00—5 young owls; desert cottontail rabbit
5/29-5/31/01—1 adult owl with prey
7/3-7/5/01—Desert cottontail rabbit; antelope ground squirrel; rodent

Appendix F

Equipment and Material Costs and Time Required to Use the TrailMaster® Camera System to Document Owl Reproduction.

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ITEM		COST*
TM 1500 camera system		$550.00
TM portable data collector		$250.00
StatPack® software and cable		$150.00
Film		$ 7.29
Film developing (1 hour, full roll)		$ 8.64
12 C-cell alkaline batteries		$ 13.50
Camera battery		$ 6.26
Extra camera cable (each)		$ 10.00
	Total	$995.69

TASK		TIME
TM1500 camera set up		15 minutes
TM1500 camera take down		10 minutes
Uploading data		10 minutes
Photo analysis and labeling (full roll)		50 minutes
	Total	85 minutes

*=Year 2003 dollars

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Appendix G

Owl Sighting Data, Including Climatic Variables and Flushing Information (DNC=Data Not Collected).

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Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
1	3/20/2001	1:30:00 PM	2	22.4	25.0	0-5	S	85	24, 22	W,W
Comments:	One flushed at 24m, one at 22 m while walking									
1	4/18/2001	2:00:00 PM	1	25.0	26.8	10-20	S	40	8	W
Comments:	Owl at B, flushed at 8m while walking									
2	3/20/2001	11:30:00 AM	2	21.3	24.0	0-5	S	85	26, 31	V, V
Comments:	One on fence post at A flushed at 26m stopped in vehicle; One on fence post at B flushed at 31m stopped in vehicle									
2	5/9/2001	11:20:00 AM	1	31.3	36.2	5-11	S	5	17	V
Comments:	Owl at A, flushed at 17m to moving vehicle									
2	5/18/2001	9:55:00 AM	1	30.0	32.5	0-9	DNC	10	30	V
Comments:	1 owl flushed to vehicle (30m)									
2	5/21/2001	2:30:00 PM	1	30.5	33.5	2-10	DNC	0	20	W
Comments:	1 owl flushed to walking at 20m									
2	6/13/2001	7:20:00 PM	2	21.9	DNC	5-10	NW	0	DNC	DNC
Comments:	2 owls									
2	6/22/2001	5:17:00 PM	2	36.1	39.5	6-15	S	15	9, 12	V,W
Comments:	1 owl flushed at 9m to stopped vehicle and 1 at 12 m to walking									
3	5/24/1999	11:35:00 AM	2	19.0	22.8	0-5	SE	50	18, 20	DNC
Comments:	Owl on post, Owl on ground (cackled)									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
3	3/20/2001	11:05:00 AM	1	21.7	DNC	0-6	S	85	DNC	DNC
Comments:	Owl near A flushed and bobbed up and down									
3	5/14/2001	2:00:00 PM	2	29.5	31.6	6-11	S	0	50, 15	V, V
Comments:	One owl flushed to vehicle at 50m, one at 15m									
3	5/23/2001	12:15:00 PM	1	34.3	39.5	4-10	NE	10	37	W
Comments:	Owl at A, flushed at 37m while walking									
3	6/13/2001	7:23:00 PM	1	21.9	DNC	5-10	NW	0	DNC	DNC
Comments:	1 owl									
3	6/25/2001	3:15:00 PM	1	31.1	32.6	10-15	S	50	8	W
Comments:	Owl at B, flushed at 8m while walking									
3	6/25/2001	3:05:00 PM	1	31.1	32.6	10-15	S	50	6	V
Comments:	Owl on apron of C, flushed at 6m while stopped in truck									
4	3/20/2001	11:45:00 AM	2	DNC	DNC	0-5	S	85	DNC	DNC
Comments:	2 owls on separate fence posts									
4	4/18/2001	1:00:00 PM	1	26.8	29.3	10-20	S	35	22	W
Comments:	Owl near B, flushed at 22m while walking									
4	5/9/2001	11:30:00 AM	2	31.3	36.2	5-11	S	5	26, 26	W, W
Comments:	Both owls flushed at 26m while walking									
4	6/13/2001	7:16:00 PM	2	21.9	DNC	5-10	NW	0	DNC	DNC
Comments:	2 owls									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
4	7/25/2001	DNC	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl at D									
4	8/29/2001	1:30:00 PM	1	37.4	39.3	4-12	SW	5	35	W
Comments:	Owl near A and B, flushed at 35m while walking									
4	9/20/2001	1:30:00 PM	1	32.3	35.7	6-14	SE	0	DNC	DNC
Comments:	Owl at CDE									
5	2/3/1998	10:00:00 AM	1	10.0	DNC	0-5	S	100	DNC	DNC
Comments:										
5	2/2/1999	11:40:00 AM	1	13.4	DNC	0-5	N	0	DNC	DNC
Comments:										
8	9/30/1999	12:00:00 PM	1	31.6	33.7	0-5	SW	0	20	DNC
Comments:	Owl flushed from burrow A entrance									
8	3/20/2001	11:15:00 AM	1	21.3	DNC	0-6	S	85	DNC	DNC
Comments:	Owl near A flushed and called									
8	4/18/2001	12:40:00 PM	1	26.3	29.6	10-20	S	35	12	V
Comments:	Owl near A, flushed at 12m while stopped in vehicle									
8	5/16/2001	11:30:00 AM	1	29.0	29.7	0-1	DNC	70	20	W
Comments:	Owl flushed to me walking at 20m from 5 ft perch (pole)									
8	5/18/2001	9:30:00 AM	2	29.5	33.5	0-9	DNC	10	10,4	W,W
Comments:	2 owls at A, 1 flushed from top of metal box at 10m while walking, 1 flushed from apron at 4m while walking									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
8	5/23/2001	12:30:00 PM	2	36.6	40.8	0-5	SW	10	42, 17	V, W
Comments:	One owl on post at A, flushed at 42m while stopped in vehicle; one owl on post at C, flushed at 17m while walking									
8	6/13/2001	7:30:00 PM	1	DNC	DNC	5-10	NW	0	DNC	DNC
Comments:	1 owl									
8	6/25/2001	4:20:00 PM	7	32.0	33.6	10-20	S	40	19, 18	W, V
Comments:	3 owls at C, flushed at 19m while walking; 4 owls at A, flushed at 18m while stopped in vehicle									
8	6/27/2001	1:07:00 PM	1	33.6	34.6	9-17	S	0	5	W
Comments:	1 owl flushed to walking at 5m									
9	6/16/1999	8:30:00 AM	1	25.5	26.8	0-5	SW	10	DNC	DNC
Comments:	Owl on apron of south burrow as I drove by									
9	6/26/1999	11:50:00 AM	1	29.0	34.2	0-5	SW	0	20	DNC
Comments:	Owl perched on fourwing saltbush; stayed close after flushing									
9	7/19/1999	1:50:00 PM	2	31.2	35.3	0-5	SE	DNC	DNC	DNC
Comments:	One owl on apron; one on rock on top of roadcut									
9	7/23/1999	11:45:00 AM	2	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:										
9	7/27/1999	10:30:00 AM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl flushed from south burrow									
9	8/4/1999	3:15:00 PM	2	33.3	37.6	0-7	SE	15	DNC	DNC
Comments:	One owl at A, one owl at B									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
10	10/4/2000	3:20:00 PM	1	26.7	26.8	5-10	SW	75	6	V
Comments:	Owl on apron flushed at 6m while in truck									
11	5/21/1998	2:30:00 PM	2	18.3	DNC	DNC	DNC	40	DNC	DNC
Comments:	2 owls									
11	6/16/1999	10:00:00 AM	0	NA	NA	NA	NA	NA	NA	NA
Comments:	Owl wing; appeared that owl had been killed									
11	4/24/2000	11:10:00 AM	1	18.8	23.5	0-5	NE	0	80	W
Comments:	Owl flushed at 80m while walking									
13	12/15/1997	3:00:00 PM	1	11.6	DNC	5	DNC	0	30	DNC
Comments:	Found during Road Survey on North Route									
14	1/7/1998	1:20:00 PM	1	12.4	10.0	0-5	S	10	DNC	DNC
Comments:										
14	2/18/1998	2:40:00 PM	1	DNC	DNC	0	NA	DNC	DNC	DNC
Comments:	Basking on apron									
14	3/4/1998	4:00:00 PM	2	14.0	DNC	0-5	SE	DNC	DNC	DNC
Comments:	1 owl larger and darker; 1 owl smaller and lighter									
14	3/25/1998	1:25:00 PM	1	10.2	DNC	5-10	S	100	DNC	DNC
Comments:										
14	11/17/1998	3:45:00 PM	1	14.3	DNC	0-5	W	0	20	DNC
Comments:										

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
14	1/6/1999	DNC	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:										
14	1/19/1999	10:40:00 AM	1	11.3	DNC	0-5	S	100	DNC	DNC
Comments:										
14	2/17/1999	11:00:00 AM	2	16.0	23.2	0-5	S	20	44, 32	DNC
Comments:	1 owl at each entrance									
14	3/17/1999	1:40:00 PM	2	21.6	25.8	0-5	W	20	21, 21	DNC
Comments:	1 owl at each entrance									
14	4/20/1999	11:43:00 AM	2	25.5	29.5	5-10	N	60	DNC	DNC
Comments:	Owls were at Burrow C in fenced area									
14	5/5/1999	6:00:00 PM	1	DNC	DNC	DNC	DNC	0	DNC	DNC
Comments:	1 on apron at D									
14	5/24/1999	3:00:00 PM	1	19.5	20.0	0-5	SW	60	DNC	DNC
Comments:	Owl on apron									
14	6/22/1999	2:00:00 PM	0	NA	NA	NA	NA	NA	NA	NA
Comments:	Owl feathers everywhere; appeared that owl had been killed									
14	8/4/1999	1:40:00 PM	1	36.6	DNC	5-10	SE	50	DNC	DNC
Comments:	Owl near apron									
14	4/6/2000	11:10:00 AM	1	25.0	27.0	0-2	DNC	DNC	66	W
Comments:	Owl ducked in burrow at 66m while getting out of truck									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
14	4/14/2000	2:40:00 PM	1	10.0	10.1	5-15	SW	100	53	V
Comments:	Ducked in east burrow at 53m from moving vehicle									
14	4/17/2000	DNC	1	21.0	DNC	0-4	S	80	30	W
Comments:	Owl at C (in fenced area); flushed at 30m while getting out of vehicle									
14	12/11/2000	2:15:00 PM	1	11.4	12.0	0-2	N	95	DNC	DNC
Comments:	Owl at culvert inside fenced area									
14	3/20/2001	3:20:00 PM	1	22.7	24.7	5-10	S	50	DNC	DNC
Comments:	Owl at culvert inside fenced area									
15	2/17/1999	10:50:00 AM	1	13.8	18.5	0-5	S	25	25	DNC
Comments:	went back into burrow									
15	3/3/1999	11:00:00 AM	1	18.7	20.9	10-15	S	5	35	DNC
Comments:	went back into burrow; back out 10 minutes later									
15	3/17/1999	1:00:00 PM	2	24.4	DNC	0-5	S	10	20, 12	DNC
Comments:	both owls bobbed and called; 1 back into burrow									
15	4/13/1999	6:40:00 PM	2	22.7	23.0	10-15	N	DNC	DNC	DNC
Comments:	Both on apron									
15	4/20/1999	11:15:00 AM	2	22.3	24.7	5-10	N	60	DNC	DNC
Comments:	Both owls on apron (1 light- and 1 dark-colored)									
15	5/5/1999	6:20:00 PM	2	22.8	24.0	0-5	N	0	DNC	DNC
Comments:	1 on post and 1 on apron									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
15	5/24/1999	2:40:00 PM	2	24.5	27.5	0-5	SW	60	DNC	DNC
Comments:	Both owls on apron									
15	6/14/1999	12:00:00 PM	1	35.4	38.8	8-15	SW	10	DNC	DNC
Comments:	Owl on apron									
15	6/16/1999	11:00:00 AM	1	DNC	DNC	5-10	SW	10	DNC	DNC
Comments:	Owl on apron									
15	7/27/1999	9:50:00 AM	2	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:										
15	8/4/1999	1:30:00 PM	1	32.7	35.5	5-10	S	50	DNC	DNC
Comments:	Owl on apron									
15	8/24/1999	12:10:00 PM	2	37.0	42.5	3-12	S	40	DNC	DNC
Comments:	Both owls on apron									
15	9/3/1999	12:10:00 PM	2	26.6	33.3	0-5	SW	0	DNC	DNC
Comments:	Both owls on apron									
15	2/15/2000	12:25:00 PM	1	16.7	19.3	0-5	N	40	DNC	DNC
Comments:	Owl on apron, ducked into burrow									
15	3/8/2000	10:45:00 AM	1	7.2	7.7	7-12	S	100	DNC	DNC
Comments:	Owl did not flush; I was within 5-10 meters of it the whole time									
15	3/13/2000	2:40:00 PM	1	26.5	28.1	0-5	NW	0	7	W
Comments:	Owl on apron; ducked into burrow at 7m while walking; came back out									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
15	3/22/2000	9:20:00 AM	2	13.5	17.3	5-10	NE	0	5	V, W
Comments:	Both owls on apron; one ducked in burrow while in truck, one flushed at 5m while walking, cackled and bobbed up and down, stayed w/in 40 m of burr									
15	4/4/2000	2:10:00 PM	1	26.5	DNC	15-20	SW	0	DNC	DNC
Comments:	Owl in burrow; hissed several times while I was near burrow									
15	4/6/2000	1:15:00 PM	1	27.7	32.0	0-5	NW	0	15	W
Comments:	Ducked in burrow at 15m walking									
15	5/11/2000	1:10:00 PM	1	16.1	20.5	5-10	N	5	15	W
Comments:	Owl on apron; flushed at 15m while walking									
15	5/15/2000	6:00:00 PM	1	21.1	21.6	15-20	S	50	12	W
Comments:	1 owl flushed at 12m while walking									
15	5/18/2000	10:25:00 AM	1	22.5	26.0	4-12	N	5	10	W
Comments:	1 owl on apron, gave territorial call; flushed at 10m while walking									
15	6/16/2000	2:50:00 PM	1	34.9	39.2	0-5	S	10	44	W
Comments:	1 owl ducked in burrow at 44m while walking									
15	6/19/2000	6:10:00 PM	2	31.4	33.2	5-15	SW	0	50	W
Comments:	Both ducked into burrow at 50m while walking									
15	6/22/2000	10:20:00 AM	2	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	2 owls at apron									
15	6/29/2000	10:20:00 AM	4	34.3	39.3	5-12	S	25	DNC	DNC
Comments:	1020-30 2 young by apron, 1 adult on post,1 adult W. of apron:1040 3 young, 1 adult on post:1049 2 young, 1 adult on post:1050 1 young into burrow									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
15	7/3/2000	7:00:00 PM	7	25.7	25.2	DNC	DNC	0	DNC	DNC
Comments:	1900-15 5 young, 1 adult on post, 1 adult by gray pipe:1915-45 1 young into burrow and back out, 5 young by apron, 1 adult on post, 1 adult by gray pi									
15	7/6/2000	6:00:00 PM	3	DNC	DNC	10-16	SW	0	DNC	DNC
Comments:	1800-1815 2 young on apron, 1 adult by gray pipe: 1815-1845 2 young near apron, 1 adult by gray pipe									
15	7/6/2000	10:00:00 AM	3	26.6	31.1	5-11	SW	0	DNC	DNC
Comments:	1000-1015 2 young on apron, 1 adult by gray pipe: 1015-1045 2 young on apron, 1 adult by gray pipe									
15	7/10/2000	6:00:00 PM	1	DNC	DNC	0-5	SW	0	59	W
Comments:	1800-1815 1 adult owl: 1815-1845 1 adult owl: Vehicle parked at 65m from burrow: flushed at 59m while walking									
15	7/24/2000	12:00:00 PM	1	36.8	40.2	0-6	S	5	7	V
Comments:	1 owl flew out of burrow at 7m while in vehicle									
15	3/20/2001	2:10:00 PM	2	23.2	25.6	0-5	S	50	20, 23	W,W
Comments:	One owl flushed at 20m and one at 23m while walking									
15	4/18/2001	2:55:00 PM	1	23.0	23.6	10-20	S	85	28	W
Comments:	Owl flushed at 28m while walking									
15	5/23/2001	3:35:00 PM	1	35.1	39.1	0-5	SW	10	43	V
Comments:	Owl flushed at 43m while moving in truck; owl hissing like rattlesnake inside burrow									
15	6/15/2001	6:10:00 PM	2	31.7	33.8	5-10	S	0	16, 22	V
Comments:	1 owl on post flushed at 16m, 1 owl on apron ducked in burrow at 22m									
15	6/18/2001	6:25:00 PM	2	33.7	35.1	9-13	DNC	0	16, 5	V,V
Comments:	1 adult flushed to moving vehicle, 1 young ducked in burrow									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
15	6/25/2001	6:50:00 PM	4	28.6	29.2	10-20	S	50	25,16,16	V, W, W
Comments:	One owl ducked in burrow at 25m while moving in truck; one owl flushed at 16m while walking; one ducked in burrow at 16m while walking									
15	7/25/2001	3:50:00 PM	2	31.7	33.9	5-11	SE	60	20, 15	V, V
Comments:	One owl flushed at 20m and one at 15m while moving in vehicle									
16	6/9/1998	8:00:00 AM	1	DNC	DNC	DNC	DNC	0	DNC	DNC
Comments:										
16	5/24/1999	5:45:00 PM	1	17.0	17.7	0-5	S	30	11	DNC
Comments:	Owl perched on shrub across road from burrow									
16	6/24/1999	1:15:00 PM	1	31.7	35.3	10-25	SW	0	DNC	DNC
Comments:										
16	10/4/2000	12:10:00 PM	1	29.5	32.8	0-8	SW	10	12	V
Comments:	Owl flushed at 12m while slowing down in vehicle									
17	6/15/1997	DNC	3	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Frank Eck saw several owls here, probably nest with young									
17	3/31/1999	7:30:00 AM	2	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owls seen by Bob ("Killer") who works at BEEF									
17	4/19/1999	6:55:00 PM	2	24.9	25.3	5-10	S	0	DNC	DNC
Comments:	Both owls on apron at D									
17	4/20/1999	11:55:00 AM	1	26.8	31.3	5-12	N	50	DNC	DNC
Comments:	Owl at B									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
17	6/16/1999	12:00:00 PM	2	31.9	34.9	10-15	SW	10	DNC	DNC
Comments:	Owls on apron									
19	7/10/1999	7:40:00 PM	1	24.7	DNC	5-10	N	80	DNC	DNC
Comments:	One owl on pipe									
20	6/5/1997	DNC	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Paul saw owl									
20	3/25/1998	1:55:00 PM	1	10.3	DNC	5-10	S	DNC	DNC	DNC
Comments:										
21	6/2/1998	9:30:00 AM	2	DNC	DNC	5-10	DNC	10	DNC	DNC
Comments:	2 owls 10-15m from burrow									
22	8/14/2000	10:05:00 AM	1	DNC	DNC	DNC	DNC	5	3	W
Comments:	Owl flushed at Burrow B at 3 meters while walking									
23	5/5/1999	10:35:00 AM	1	19.0	22.0	3-5	DNC	0	DNC	DNC
Comments:	Owl flushed from burrow									
23	5/10/1999	7:04:00 PM	1	21.1	21.1	5-10	SW	70	DNC	DNC
Comments:	On mound near apron									
23	5/24/1999	9:15:00 AM	2	16.0	16.0	0-5	N	100	DNC	DNC
Comments:	Light rain; Owl on apron flushed; Owl on ground 8m from apron bobbed up and down									
23	6/29/1999	10:15:00 AM	2	35.5	39.0	0-5	SE	0	DNC	DNC
Comments:	One owl perched on bush, one on berm									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
23	7/7/1999	7:45:00 PM	2	30.6	30.8	5-10	SE	40	DNC	DNC
Comments:	One adult owl on berm; one small gray chick inside burrow									
23	7/10/1999	7:15:00 PM	1	26.2	DNC	5-10	N	80	DNC	DNC
Comments:										
23	7/30/1999	1:30:00 PM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl flushed from shrubs near burrow									
23	8/4/1999	10:00:00 AM	2	33.3	35.3	0-5	S	5	DNC	DNC
Comments:	Both owls on berm									
23	8/6/1999	5:20:00 PM	1	30.4	31.7	10-20	S	5	DNC	DNC
Comments:	Owl on berm									
29	9/20/2001	11:00:00 AM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Flushed from a predator burrow									
30	11/5/1997	1:20:00 PM	1	27.5	19.3	2-5	S	0	DNC	DNC
Comments:	1 owl									
30	3/25/1998	9:30:00 AM	1	14.0	13.4	0-5	S	70	DNC	DNC
Comments:										
30	3/3/1999	10:15:00 AM	1	DNC	20.0	DNC	DNC	DNC	DNC	DNC
Comments:	owl stayed around (territorial?)									
30	3/18/1999	11:40:00 AM	2	DNC	24.0	DNC	DNC	DNC	DNC	DNC
Comments:										

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
30	4/15/1999	10:00:00 AM	4	17.5	DNC	DNC	DNC	0	DNC	DNC
Comments:	2 pairs of owls seen, 1 pair at each burrow									
30	4/20/1999	3:30:00 PM	3	DNC	DNC	5-10	DNC	50	DNC	DNC
Comments:	2 in shade at A; 1 at B on apron									
30	6/3/1999	3:45:00 PM	2	17.3	19.3	5-15	S	DNC	DNC	DNC
Comments:	One owl at west burrow; one owl at east burrow									
30	6/7/1999	1:10:00 PM	1	26.8	30.7	5-10	DNC	DNC	DNC	DNC
Comments:	Owl at burrow entrance sitting in shade									
30	6/29/1999	11:20:00 AM	1	38.0	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl at west burrow									
30	7/19/1999	3:15:00 PM	1	33.2	35.2	0-10	SE	DNC	DNC	DNC
Comments:	Owl near east burrow									
30	7/21/1999	1:30:00 PM	1	34.2	38.0	0-5	SW	DNC	DNC	DNC
Comments:	Owl flushed from east burrow									
30	7/23/1999	9:30:00 AM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl flushed from east burrow									
30	8/4/1999	DNC	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl flushed from shrub above west burrow									
30	8/17/1999	6:45:00 PM	1	34.0	DNC	0-5	SW	25	DNC	DNC
Comments:	Owl at west burrow									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
30	4/24/2000	3:20:00 PM	2	DNC	DNC	DNC	DNC	0	135, 33	V, W
Comments:	1 owl flushed from west to east burrow at 135m from moving vehicle; 2nd owl landed near first and both flushed at 33m walking									
30	5/9/2000	11:40:00 AM	1	28.0	DNC	0-8	S	60	50	W
Comments:	Owl at East burrow; flushed at 50m while walking									
30	6/5/2000	12:15:00 PM	4	33.0	33.0	8-16	S	10	15	W
Comments:	1 owl flushed at 15m while walking; 4 owls on apron of east burrow									
30	6/12/2000	10:15:00 AM	4	30.0	30.5	0-8	SW	85	130,130,130,25	W,W,W,W
Comments:	1 owl on ledge above B, flushed at 25m while walking; 3 owls on apron at B, ducked in at 130m while leaving vehicle									
30	7/6/2000	12:55:00 PM	3	29.2	34.3	10-17	SW	0	DNC	DNC
Comments:	1 owl at A; 2 owls at B									
30	7/13/2000	6:00:00 PM	6	36.7	39.1	DNC	DNC	50	122	V
Comments:	3 owls at A; 3 owls at B; some flushed from A to B at 122m while in vehicle									
30	7/17/2000	8:30:00 AM	2	29.3	30.1	5-10	SW	0	142,82	W,W
Comments:	2 owls at B; 1 flushed at 142m and one at 82m while walking									
30	9/6/2000	12:00:00 PM	2	DNC	DNC	0-1	N	0	35	W
Comments:	1 owl at A flushed at 35m while walking; 1 owl at B									
30	10/4/2000	1:10:00 PM	1	32.5	34.5	0-5	S	25	45	W
Comments:	Owl flew from west burrow to east burrows; flushed at 45m while walking									
30	3/21/2001	10:00:00 AM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl at East Burrow									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
30	4/18/2001	DNC	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments: Owl at B										
32	3/4/1998	DNC	1	10.7	DNC	0-3	S	DNC	DNC	DNC
Comments:										
32	3/17/1998	10:30:00 AM	2	DNC	DNC	DNC	DNC	0	DNC	DNC
Comments:										
32	3/3/1999	DNC	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:										
32	3/30/1999	DNC	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:										
32	5/24/1999	2:00:00 PM	1	25.5	DNC	DNC	DNC	DNC	DNC	DNC
Comments:										
32	6/7/1999	2:10:00 PM	1	30.2	33.9	7-12	DNC	DNC	DNC	DNC
Comments: Owl at burrow entrance										
32	4/30/2001	3:05:00 PM	1	32.1	DNC	0-5	SW	0	DNC	DNC
Comments: 1 owl										
33	7/3/2000	5:20:00 PM	1	31.6	34.5	DNC	DNC	0	50	W
Comments: 1 owl flushed at 50m while walking										
33	7/6/2000	12:05:00 PM	2	30.2	34.2	10-19	SW	0	55,40	W,W
Comments: 2 owls, 1 flushed at 55m and one at 40m while walking										

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
33	8/7/2000	10:20:00 AM	2	DNC	DNC	0-1	DNC	0	40,40	W,W
Comments:	2 owls on apron; 1 flushed (flew) and 1 ducked in burrow at 40m while walking									
33	3/20/2001	4:55:00 PM	2	DNC	DNC	0-5	S	20	36, 7	W,W
Comments:	One flushed at 36m and one at 7m while walking									
35	6/5/2000	9:50:00 AM	2	34.0	DNC	5-12	S	20	50,60	W
Comments:	1 owl flushed at 50m and 1 at 60m while walking; 1 flushed from shade of caliche overhang; 33C in shade									
36	11/6/1997	9:00:00 AM	1	19.0	18.0	0-2	SE	0	DNC	DNC
Comments:										
36	11/17/1998	4:00:00 PM	1	16.5	DNC	0-2	DNC	0	60	W
Comments:	owl flushed at 60 m to walking									
36	3/30/1999	8:35:00 AM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:										
36	6/11/1999	2:00:00 PM	1	33.8	37.8	5-13	SW	5	DNC	DNC
Comments:										
36	8/13/1999	1:20:00 PM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl flushed from 5 meters west of burrow									
36	9/30/1999	9:40:00 AM	1	24.5	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl flushed									
36	12/9/1999	9:30:00 AM	1	4.5	7.0	DNC	DNC	DNC	DNC	DNC
Comments:										

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
38	3/17/1999	3:10:00 PM	1	20.1	26.5	0-5	S	10	19	DNC
Comments:										
38	4/20/1999	1:40:00 PM	1	25.4	28.8	5-10	N	20	20	DNC
Comments:	On apron at B									
38	4/21/1999	3:45:00 PM	2	22.0	DNC	5-15	DNC	10	DNC	DNC
Comments:	Pair observed at burrow entrance									
38	5/24/1999	5:40:00 PM	1	16.7	17.3	0-5	S	20	15	DNC
Comments:	Owl on apron									
38	6/24/1999	1:10:00 PM	1	31.2	34.6	10-23	SW	0	DNC	DNC
Comments:	Owl on apron									
38	6/29/1999	2:50:00 PM	1	37.3	41.0	5-10	SE	DNC	DNC	DNC
Comments:	Owl perched on camera post									
38	4/4/2000	10:25:00 AM	2	22.6	21.3	5-10	S	0	30, 30	V, W
Comments:	Both owls on apron in shade; 1 owl flushed to shrub and bobbed at 30m while in truck; 1 owl flushed at 30m while walking									
38	4/10/2000	11:30:00 AM	1	16.2	18.8	7-13	DNC	50	8	V
Comments:	Flushed at 8m from moving vehicle									
38	4/27/2000	10:20:00 AM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl on apron in shade, did not flush as I drove past									
38	5/8/2000	1:20:00 PM	1	27.0	DNC	0-5	S	DNC	DNC	DNC
Comments:	Flushed at unknown distance									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
38	5/22/2000	11:40:00 AM	1	33.0	31.6	2-12	S	10	100	V
Comments:	Owl on apron flushed to approching vehicle (me) at about 100m away-flew to shrub near burrow									
38	6/5/2000	6:35:00 PM	2	30.0	33.0	5-10	S	0	16,28	V, V
Comments:	1 flushed at 28m and 1 at 16m while in truck; 1 above burrow A on black sagebrush, 1 above burrow B									
38	6/22/2000	12:40:00 PM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	1 owl at B									
38	6/26/2000	9:15:00 AM	1	27.6	28.1	0-1	S	DNC	50	W
Comments:	1 adult on shrub near A; flushed at 50m while getting out of vehicle									
38	9/12/2000	3:00:00 PM	1	32.0	DNC	0-5	S	20	10	V
Comments:	Owl flushed at 10m while moving in vehicle									
38	2/21/2001	10:30:00 AM	1	10.5	11.5	0-2	S	30	17	V
Comments:	Owl at B flushed or ducked in burrow at 17m stopped in vehicle									
39	11/24/1998	10:30:00 AM	1	15.0	32.0	0	NA	20	12	DNC
Comments:	Owl in sun near burrow entrance, flushed at 12m									
41	3/17/1999	12:45:00 PM	1	27.0	30.5	0-5	S	10	DNC	DNC
Comments:	Owl bobbed 2-3 times before flushing									
41	8/31/1999	1:40:00 PM	2	28.1	32.3	5-10	S	0	DNC	DNC
Comments:	One owl at B; one owl at C									
41	3/13/2000	2:20:00 PM	1	21.6	22.8	0-5	NW	0	47	V
Comments:	Owl near F Burrow; flushed at 47m while I was in vehicle									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
41	3/22/2000	11:05:00 AM	1	17.5	20.5	0-8	NE	0	14	W
Comments:	Owl on apron; flushed at 14 m while walking									
43	5/24/1999	9:25:00 AM	2	17.3	17.5	0-5	N	90	19, 20	DNC
Comments:										
43	6/24/1999	10:35:00 AM	1	36.5	39.5	0-5	SE	0	DNC	DNC
Comments:										
43	7/10/1999	7:25:00 PM	1	24.2	DNC	5-10	N	80	DNC	DNC
Comments:										
43	8/4/1999	10:15:00 AM	1	33.7	36.0	0-5	S	5	DNC	DNC
Comments:	Owl perched on camera									
43	9/30/1999	9:10:00 AM	1	27.7	29.3	0-5	N	0	17	DNC
Comments:	Owl flushed from top of washbank									
43	3/13/2000	9:00:00 AM	2	17.8	19.6	0-5	NE	0	16	W
Comments:	Owls near apron; both flushed at 16m while walking									
43	3/14/2000	12:10:00 PM	1	29.0	31.1	0-5	N	10	DNC	DNC
Comments:	Owl just off of apron; Flushed but did not get distance									
43	3/22/2000	8:00:00 AM	1	12.3	14.5	5-7	NE	0	22	W
Comments:	Owl on apron; flushed at 22m while walking									
43	4/4/2000	8:55:00 AM	1	21.5	22.8	0-5	SE	0	48	W
Comments:	Owl on apron; ducked in burrow at 48m while walking									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
43	7/3/2000	6:15:00 PM	2	29.7	30.7	5-12	S	0	33	V
Comments: 1 flew and perched on shrub; 1 on fourwing saltbush flushed at 33m while in vehicle										
43	7/6/2000	11:25:00 AM	1	28.7	31.5	5-15	S	0	22	W
Comments: 1 owl flushed at 22m while walking										
43	4/18/2001	9:45:00 AM	1	24.0	27.0	10-15	S	35	9	W
Comments: Owl flushed at 9m while walking										
43	5/23/2001	10:15:00 AM	1	32.2	37.6	2-8	SE	15	23	W
Comments: Owl flushed at 23m while walking										
43	5/31/2001	2:05:00 PM	1	35.2	42.0	3-8	SE	0	14	W
Comments: Owl flushed at 14 m from burrow while walking										
44	2/11/1999	9:40:00 AM	1	4.0	DNC	0-8	N	0	DNC	DNC
Comments:										
44	8/14/2000	2:30:00 PM	1	36.0	DNC	0-8	DNC	0	30	W
Comments: Owl flushed from Burrow B at 30 m while walking										
44	9/6/2000	1:30:00 PM	1	DNC	DNC	0-1	N	0	25	W
Comments: 1 owl flushed at 25m while walking										
49	8/31/1999	1:20:00 PM	1	28.0	DNC	5-10	S	0	DNC	DNC
Comments: Flushed to fence post										
50	8/31/1999	DNC	1	28.5	DNC	8-15	DNC	DNC	DNC	DNC
Comments: Owl flushed from apron										

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
50	9/30/1999	2:50:00 PM	1	35.0	DNC	2-3	DNC	0	DNC	DNC
Comments:	Owl flushed									
51	4/20/1999	10:05:00 AM	1	22.5	24.0	5-10	N	100	15	DNC
Comments:	Owl at B, flew and bobbed up and down									
51	7/10/2000	2:45:00 PM	1	DNC	DNC	5-10	S	0	DNC	DNC
Comments:	1 owl at burrow D									
51	8/29/2001	4:00:00 PM	3	35.6	37.8	3-7	SW	15	55	V
Comments:	Owls flushed at about 55m while moving in vehicle									
54	4/7/1999	6:05:00 PM	1	DNC	DNC	5-10	W	100	20	DNC
Comments:										
58	9/30/1999	12:55:00 PM	1	29.8	37.8	0-5	S	0	DNC	DNC
Comments:	Owl flushed from burrow A entrance									
58	7/26/2000	1:45:00 PM	1	DNC	DNC	DNC	DNC	0	DNC	DNC
Comments:										
58	8/14/2000	DNC	1	36.0	DNC	2-4	DNC	15	5	V
Comments:	Owl flushed at 5m while driving in truck									
58	9/6/2000	12:35:00 PM	1	25.0	34.0	5-10	N	0	11	V
Comments:	1 owl at A ducked in burrow at 11m while in truck									
59	5/5/1999	4:00:00 PM	2	22.9	28.5	0-5	SW	0	14, 11	DNC
Comments:	Both owls on apron									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
59	5/24/1999	1:40:00 PM	1	24.6	28.3	0-5	N	75	DNC	DNC
Comments:	Owl on apron									
59	6/19/1999	11:40:00 AM	1	33.0	37.2	5-15	S	10	DNC	DNC
Comments:	Owl perched on fence post; Retrieved TM1500 at 10:50 am same day									
59	7/26/1999	4:15:00 PM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl flushed from west culvert									
59	9/30/1999	12:25:00 PM	1	31.0	34.0	5-10	S	0	DNC	DNC
Comments:	Owl at burrow A; flushed to north									
59	4/6/2000	11:50:00 AM	1	25.5	28.6	6-15	NW	0	21	V
Comments:	Owl flushed at 21m while stopped in 2 trucks									
59	6/6/2001	2:10:00 PM	1	35.5	36.8	DNC	DNC	0	70	W
Comments:	Owl flushed to walking at 70m									
59	6/6/2001	3:05:00 PM	1	36.3	38.7	2-10	S	5	20	V
Comments:										
59	6/6/2001	3:05:00 PM	2	36.3	38.7	2-10	S	5	15,20	W,V
Comments:	1 owl flushed from apron at 15m while walking, 1 owl flushed from 5 ft perch at 20m to moving vehicle									
59	6/15/2001	5:00:00 PM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	1 owl at A									
59	6/25/2001	4:40:00 PM	2	30.9	32.6	10-20	S	40	11, 4	W, W
Comments:	Adult owl flushed at 11m while walking, young owl flushed at 4m while walking									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
61	5/5/1999	12:00:00 PM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl perched on post and then flew to ground									
61	5/24/1999	6:25:00 PM	1	19.6	19.8	0-5	NW	10	20	DNC
Comments:	Owl flushed from apron									
61	8/4/1999	3:50:00 PM	1	35.5	37.0	5-10	S	10	DNC	DNC
Comments:	Owl on apron									
63	5/24/1999	12:30:00 PM	1	17.5	18.3	0-5	S	60	DNC	DNC
Comments:	Owl on apron flushed as I drove by									
64	5/24/1999	1:10:00 PM	1	21.2	24.2	0-5	SW	60	60	W
Comments:	Flew toward North of 8D-2 Burrow; saw it at latter and flushed back to Drill Pad									
64	6/16/1999	1:30:00 PM	1	33.5	35.5	10-20	SW	10	DNC	DNC
Comments:	Owl on mound near apron									
64	6/19/1999	11:15:00 AM	1	31.0	36.6	5-13	S	10	DNC	DNC
Comments:	Owl on apron									
64	6/29/1999	12:20:00 PM	2	37.0	41.0	0-5	SE	DNC	DNC	DNC
Comments:	Both on apron									
64	8/4/1999	DNC	1	34.5	38.5	8-12	SE	50	DNC	DNC
Comments:	Owl on apron									
64	8/4/1999	5:50:00 PM	2	33.8	34.0	5-12	S	20	DNC	DNC
Comments:	One adult owl on apron, one young owl on berm near apron									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
64	8/31/1999	12:20:00 PM	2	26.5	29.0	5-8	S	0	DNC	DNC
Comments:	Two owls on apron									
64	8/31/1999	4:50:00 PM	3	28.0	30.0	8-12	S	0	DNC	DNC
Comments:	Three owls on apron									
64	9/3/1999	12:25:00 PM	3	26.1	35.0	0-5	SW	0	DNC	DNC
Comments:	All three on apron									
64	9/30/1999	12:40:00 PM	1	28.5	34.3	5-10	S	0	DNC	DNC
Comments:	Owl at burrow C; flushed to south									
64	10/27/1999	1:00:00 PM	1	24.9	28.5	5-10	S	50	DNC	DNC
Comments:	Owl at burrow C apron									
64	2/15/2000	DNC	1	13.9	17.5	0-5	N	80	DNC	DNC
Comments:	Owl on apron, ducked into burrow									
64	3/8/2000	9:50:00 AM	1	4.2	4.8	7-12	S	100	15	V
Comments:	Owl on apron of burrow B; ducked into apron while I was in vehicle at 15m									
64	3/13/2000	1:05:00 PM	1	20.2	24.8	0-5	W	0	DNC	DNC
Comments:	Owl on apron of burrow B, ducked into burrow									
64	3/22/2000	3:00:00 PM	1	21.0	24.0	0-5	SE	0	18	V
Comments:	Owl on burrow B apron; ducked in burrow at 18m while stopped in vehicle									
64	4/4/2000	12:20:00 PM	1	25.3	19.0	11-16	S	0	DNC	DNC
Comments:	Owl in pipe at Burrow D in shade									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
64	4/6/2000	12:00:00 PM	1	26.8	28.6	0-18	NW	0	DNC	DNC
Comments:	Owl at Burrow E									
64	5/8/2000	4:00:00 PM	2	DNC	DNC	DNC	DNC	DNC	57, 52	V, W
Comments:	1 owl flushed at 57m moving slow in vehicle, 1 owl flushed at 52m while walking									
64	5/18/2000	12:00:00 PM	1	22.0	23.0	0-2	N	40	50	W
Comments:	Owl flushed from apron (burrow E) to me walking at 50M.									
64	5/22/2000	10:15:00 AM	1	31.8	DNC	0	NA	10	60	W
Comments:	Owl perched on post (6ft) flushed to me walking at 60m. This occurred north of burrow B.									
64	5/22/2000	10:30:00 AM	1	33.5	40.0	0-1	S	10	10	W
Comments:	Owl perched on post(5-6ft) flushed to me walking at 10m. Note: Direct soil temp at apron was 50C-hence owl on perch									
64	6/5/2000	3:15:00 PM	4	32.7	36.2	10-15	S	5	19	V
Comments:	1 owl at D, 1 at B, 2 at E (1 young); Owl at B flushed at 19m in truck									
64	6/7/2000	10:45:00 AM	4	DNC	DNC	DNC	DNC	0	DNC	DNC
Comments:	1045-1100 1 adult at F, 2 adults at A: 11-1130 2 adults at A: 1130-1145 1 adult at F, 1 chick at E, 2 adults at A									
64	6/16/2000	4:40:00 PM	3	35.5	40.1	0-5	SE	10	60	W
Comments:	1 young owl at A ducked in burrow at 60m getting out of vehicle; 1 owl at B; 1 owl on shrub near E									
64	6/19/2000	5:35:00 PM	2	31.8	34.0	8-12	S	0	DNC	DNC
Comments:	1 adult owl on shrub near E; 1 young owl at B									
64	6/29/2000	8:55:00 AM	3	31.5	36.5	0-5	S	25	DNC	DNC
Comments:	0855-0910 3 young at E all ducked in burrow: 0922 1 young came to entrance and ducked back in									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
64	7/3/2000	8:00:00 PM	2	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	1 adult and 1 young near E and F									
64	7/6/2000	8:35:00 AM	6	24.5	29.2	5-17	SE	0	DNC	DNC
Comments:	0835-0850 1 adult, 2 young at B 1 flew from B to A, 1 young at E: 0850-0920 1 adult, 2 young at B; 1 adult, 1 young at A; 1 young at E									
64	7/6/2000	7:05:00 PM	5	DNC	DNC	5-10	S	0	DNC	DNC
Comments:	1905-1920 1 adult at B: 1920-1950 1 adult at B, 1 adult and 3 young at A (1950)									
64	7/10/2000	7:35:00 PM	3	DNC	DNC	0-5	S	0	DNC	DNC
Comments:	1935-1950 3 young at B 1 flew away: 1950-2020 2 young at B 1 left at 2000 and 1 left at 2013: Vehicle parked at 76m from E and 55m from B									
64	7/26/2000	12:45:00 PM	3	36.5	39.0	10-16	S	0	15,15,15	W,W,W
Comments:	3 owls at A, flushed at 15m while walking; apron temp taken 6" in shade									
64	7/28/2000	4:20:00 PM	1	36.5	40.0	2-12	SW	15	18	W
Comments:	1 owl at B in burrow, flushed at 18m while walking; apron temp taken in shade of burrow where owl was									
64	8/14/2000	2:50:00 PM	3	36.0	DNC	2-4	DNC	15	10, 10, 5	V, V, W
Comments:	2 owls flushed at 10m driving in truck at Burrow A; 1 owl flushed at 5m while walking at Burrow E									
64	9/6/2000	1:00:00 PM	1	25.5	30.1	0-5	NW	0	14	V
Comments:	1 owl at G flushed at 14m while in truck									
64	9/6/2000	12:55:00 PM	1	25.7	29.1	2-10	N	0	22	V
Comments:	1 owl at A flushed at 22m while in truck									
64	10/4/2000	2:10:00 PM	1	28.2	30.1	5-10	SE	65	22	V
Comments:	Owl at A; flushed at 22m while stopped in vehicle									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
64	11/14/2000	2:10:00 PM	1	8.5	9.3	0-5	NW	25	6	V
Comments: Owl at I; flushed at 6m to moving vehicle										
64	2/13/2001	10:30:00 AM	1	4.5	4.9	5-10	N	100	11	V
Comments: Owl on apron, ducked in burrow at 11m while sitting in truck; 5" snow on drill pad										
64	3/20/2001	12:10:00 PM	2	22.0	24.7	5-10	S	85	29, 29	W, W
Comments: 2 owls at E, both flushed at 29m while walking										
64	4/18/2001	1:25:00 PM	1	25.1	29.0	10-20	S	50	80	V
Comments: Owl at E, flushed at 80m while stopped in vehicle										
64	5/2/2001	10:45:00 AM	1	13.6	DNC	10-30	N	0	DNC	DNC
Comments: 1 owl at E										
64	5/4/2001	4:40:00 PM	1	24.3	27.0	5-10	W	0	DNC	DNC
Comments: 1 owl on camera post at F										
64	6/6/2001	1:50:00 PM	2	35.3	36.8	0-6	DNC	5	15	W
Comments: 2 owls ducked in burrow to walking at 15m at B										
64	6/11/2001	2:25:00 PM	2	35.3	38.5	4-14	DNC	0	25,20	W,V
Comments: 1 owl at F flushed from 5ft perch at 25m while walking; 1 owl at E ducked in burrow at 20m to moving vehicle										
64	6/13/2001	6:40:00 PM	5	23.8	DNC	5-18	N	0	DNC	DNC
Comments: 2 Adults, 3 young at A										
64	6/15/2001	5:10:00 PM	9	33.6	35.2	3-8	S	0	DNC	DNC
Comments: 1 owl at JK, 1 owl at B, 1 owl at C, 6 owls at E										

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
64	6/25/2001	5:05:00 PM	3	30.1	34.1	10-20	S	40	30	V
Comments:	Owl at D, flushed at 30m while stopped in vehicle									
64	6/25/2001	5:30:00 PM	2	30.2	32.0	5-15	S	40	18, 13	W, W
Comments:	2 adult owls at J, one flushed at 13m one at 18m while walking									
64	8/29/2001	2:00:00 PM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl at E									
64	9/20/2001	2:00:00 PM	1	33.5	37.5	5-8	S	0	15	V
Comments:	Owl at A, flushed to B and then to North of 8D-2; Flushed at 15m to moving vehicle									
64	12/19/2001	12:30:00 PM	1	11.0	12.7	0-5	SE	70	9	V
Comments:	Owl at B, ducked in burrow at 9m while stopped in vehicle									
67	4/4/2000	DNC	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl on apron									
67	4/6/2000	12:30:00 PM	1	26.7	28.5	5-12	NW	0	44	W
Comments:	Ducked in burrow at 44m walking									
67	5/8/2000	4:20:00 PM	1	28.0	29.4	0-5	SW	15	37 ?	V, W
Comments:	Owl in shrub; flew to apron of A while I was in truck; flushed to E at 37m while walking									
67	5/11/2000	1:55:00 PM	1	DNC	DNC	5-10	N	10	29	W
Comments:	1 owl at A; flushed at 29m while walking									
67	5/15/2000	6:30:00 PM	1	20.5	21.1	DNC	DNC	20	26	W
Comments:	1 owl east of A; flushed at 26m while walking									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
67	5/18/2000	11:10:00 AM	1	23.0	27.0	8-12	N	30	50	V
Comments:	Owl flushed from apron as vehicle approched site.									
67	6/5/2000	2:50:00 PM	2	33.0	36.5	10-15	S	5	57, 57	W, W
Comments:	2 owls flushed at 57m while walking									
67	6/26/2000	11:10:00 AM	2	36.7	39.1	0-5	DNC	DNC	10	W
Comments:	2 owls at E; one flushed to vehicle unknown distance; one flushed at 10m while walking									
67	6/29/2000	9:50:00 AM	2	32.3	36.5	0-10	SE	25	65,48	V,W
Comments:	1 owl at E on fence post; flushed to burrow at 65m while in vehicle;1 owl on fence post at AC; bobbed up and down; flushed at 48m while walking									
67	7/6/2000	8:00:00 PM	9	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	9 owls, 7 young and 2 adults; some young flew									
67	7/6/2000	9:40:00 AM	2	26.6	29.0	5-15	SE	0	DNC	DNC
Comments:	2 adult owls, 1 at C and 1 at E									
67	7/10/2000	7:15:00 PM	5	DNC	DNC	0-5	SW	0	DNC	DNC
Comments:	1 adult and 4 young at A									
67	7/13/2000	5:15:00 PM	3	35.8	39.8	5-12	S	60	DNC	DNC
Comments:	3 owls at AC									
67	7/17/2000	9:35:00 AM	3	29.6	32.0	5-10	S	0	52,52,52	W,W,W
Comments:	3 owls at AC, flushed at 52m while walking									
67	7/19/2000	1:10:00 PM	1	DNC	DNC	DNC	DNC	DNC	30	V
Comments:	1 owl at AC, flushed at 30m to vehicle									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
67	8/14/2000	DNC	2	37.0	DNC	2-5	DNC	15	DNC	DNC
Comments: 1 owl flushed from A and 1 owl from B										
67	9/6/2000	1:15:00 PM	1	28.9	30.6	0-5	NW	0	18	V
Comments: 1 owl by crushed pipe flushed at 18m while in truck										
67	10/4/2000	2:25:00 PM	1	31.2	35.1	5-10	SE	50	DNC	DNC
Comments: Owl at B										
67	3/20/2001	12:50:00 PM	2	24.0	25.3	0-5	S	85	34, 22	W, W
Comments: 2 owls at A, one flushed at 34m and one at 22m while walking										
67	4/18/2001	1:50:00 PM	1	26.1	28.3	10-20	S	40	57	V
Comments: Owl near B, flushed at 57m while moving in vehicle										
67	5/7/2001	3:30:00 PM	2	31	DNC	0-6	SW	0	DNC	DNC
Comments: 1 owl at AC; 1 owl at BD										
67	5/23/2001	1:55:00 PM	1	34.1	39.0	5-10	S	10	23	W
Comments: Owl at E, flushed at 23m while walking										
67	6/11/2001	2:50:00 PM	1	34.5	38.3	4-9	DNC	5	15	W
Comments: Owl ducked in to me walking at 15m										
67	6/13/2001	10:30:00 AM	1	22.5	27.0	10-15	N	0	25	W
Comments: 1 owl flushed to me walking at 25M										
67	6/13/2001	7:00:00 PM	3	DNC	DNC	DNC	DNC	0	DNC	DNC
Comments: 3 owls at ABCD										

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
67	6/15/2001	5:45:00 PM	2	32.7	36.6	2-6	S	0	DNC	DNC
Comments:	2 owls at A									
67	7/23/2001	2:20:00 PM	1	35.0	43.3	0-7	SE	0	12	V
Comments:	1 owl ducked in burrow to miving vehicle at 12m									
67	8/29/2001	3:30:00 PM	1	36.8	39.5	4-9	SW	15	25	V
Comments:	Owl at E, flushed at 25m while moving in vehicle									
67	9/20/2001	2:20:00 PM	1	32.7	36.7	2-10	S	0	40	V
Comments:	Flew to E and back to C, bobbed up and down; Flushed at 40m to moving vehicle									
68	8/14/2000	11:15:00 AM	1	DNC	DNC	DNC	DNC	5	DNC	DNC
Comments:	Owl flushed from apron									
71	3/20/2001	4:30:00 PM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl flushed from burrow on return trip from M-16#1									
73	5/25/2001	8:30:00 AM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Owl flying									
73	6/15/2001	6:05:00 PM	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	1 owl									
73	6/25/2001	6:40:00 PM	4	28.6	29.2	10-20	S	50	21, 21, 14	W, W, W
Comments:	4 young; 2 flushed at 21m and one ducked in burrow at 14m while walking									
74	6/12/2001	4:30:00 PM	2	33.3	35.1	5-10	NW	20	6	W
Comments:	2 owls; 1 owl flushed at 6m while walking									

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
74	6/26/2001	DNC	2	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments: 2 owls										
74	7/3/2001	10:10:00 AM	2	39.6	DNC	DNC	DNC	DNC	DNC	DNC
Comments: 2 owls in shade of building										
76	6/13/2001	11:10:00 AM	1	20.1	22.3	5-15	N	0	25	V
Comments: owl at A flushed to moving vehicle at 25m										
76	6/13/2001	6:25:00 PM	6	24.1	DNC	3-10	N	0	DNC	DNC
Comments: 2 adults, 4 young at A; 2 young ducked in burrow										
76	6/15/2001	5:00:00 PM	2	DNC	DNC	3-8	S	0	DNC	DNC
Comments: 2 owls at A										
76	6/15/2001	5:30:00 PM	5	31.8	38.0	3-12	S	0	25,25,25,10, 10	V,V,V,W,W
Comments: 3 owls at Aducked in burrow to driving, 2 flushed to walking. (1 from perch)										
76	6/25/2001	4:55:00 PM	1	30.2	34.2	5-20	S	40	10	V
Comments: Owl at A, flushed at 10m while stopped in vehicle										
76	7/18/2001	DNC	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments: 1 owl on fence post at A										
76	8/29/2001	1:50:00 PM	1	34.5	38.2	3-7	SW	10	12	V
Comments: Owl at B, flushed at 12m while moving in vehicle										
82	5/12/1999	DNC	2	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments: Natural burrow; breeding pair (GT Sharp); YMP; Jim Boone, personal communication										

Site Number	Date	Time	Number of owls	Air Temp (C)	Apron Temp (C)	Wind Speed (mph)	Wind Direction	% Cloud Cover	Flushing Distance (m)	Walking/ Vehicle
106	11/25/1997	4:05:00 PM	1	13.7	DNC	0-5	N	100	DNC	DNC
Comments:	Found during Road Survey on North Route; No burrow									
107	8/19/1998	DNC	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Saw during Anabat road survey; owl standing in middle of road, possibly foraging on large grasshoppers in the area									
108	7/6/1998	DNC	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	Seen during other resource survey									
1006	1/5/1998	DNC	1	DNC	DNC	DNC	DNC	DNC	DNC	DNC
Comments:	YMP; Jim Boone, personal communication									

Appendix H

Traffic Rate, Distance to Nest Burrow (m), Productivity, and Owl Activity Data for Burrows Monitored With Traffic Counters During the Breeding Seasons of 2000 and 2001.

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Burrow Site Number	Year	Vehicles /day	Road Type	Distance to Nest (m)	Young Owls/Adults/Sign	Owl Activity Rating
61	2000	0.2	gravel	43	None	None
43	2000	0.3	paved	48	5 Young	Breeding
23	2000	0.4	paved	11	None	None
64 (Nest B)	2000	0.4	gravel	269	4 Young	Breeding
64 (Nest E)	2000	0.4	gravel	196	7 Young	Breeding
59	2000	0.4	gravel	19	3 adult owls/24 pellets/1 date	Low owl activity
15	2000	0.4	dirt	145	5 Young	Breeding
14	2000	0.6	dirt	58	1 adult/pellets/scat on 3 dates	Moderate owl activity
37	2000	3.9	paved	15	1 pellet/scat on 3 dates	Moderate owl activity
3	2000	4	gravel	11	9 pellets/scat on 1 date	Low owl activity
38	2000	5.7	paved	14	8 Young	Breeding
67	2000	10.2	paved	45	7 Young	Breeding
11	2000	12	paved	11	1 adult/1 pellet	Low owl activity
17	2000	27.8	paved	42	None	None
30	2000	40.2	paved	165	6 Young	Breeding
36	2000	140.9	paved	315	1 pellet/scat on 1 date	Low owl activity
32	2000	501.5	paved	56	pellets/scat on 2 dates	Low owl activity
8	2001	0.2	gravel	11	7 Young	Breeding
43	2001	0.23	paved	48	1 Adult/pellets/scat	Moderate owl activity
14	2001	0.38	dirt	60	1 pellet on 2 dates	Low owl activity
64 (Nest B)	2001	0.4	gravel	269	6 Young	Breeding
64 (Nest E)	2001	0.4	gravel	196	6 Young	Breeding
76	2001	0.4	gravel	120	8 Young	Breeding
15	2001	0.9	gravel	172	6 Young	Breeding
73	2001	0.9	gravel	75	7 Young	Breeding
13	2001	1	gravel	60	pellets on 2 dates	Low owl activity
2	2001	1.2	gravel	10	1 Young	Breeding
16	2001	1.44	gravel	10	pellets/scat in April	Low owl activity
3	2001	1.8	gravel	11	4 Young	Breeding
4	2001	1.9	paved	78	4 Young	Breeding
1	2001	15.4	paved	50	pellets/scat/3 dates	Moderate owl activity
67	2001	21.7	paved	45	pellets/scat/owl on 5 dates	High owl activity
30	2001	70.3	paved	165	pellet/scat in April	Moderate owl activity
32	2001	487.8	paved	65	3 Young	Breeding
33	2001	617.4	paved	287	1 adult/pellet/scat	Low owl activity
71	2001	617.4	paved	138	pellets/scat/March/April	Low owl activity

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Appendix I

Summary of Linear Regression Analysis Results.

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Burrowing Owl Variables[a] Regressed	Sample Size (n)	R2 Value	p-Value[b]	Equation of Line
Site characteristics				
BURS vs. number of burrow openings per site	56	0.12	0.01	y = .0373 x + .1925
BURS vs. burrow aspect	19	0.37	0.01	y = .0010 x + .0965
Distance to potential disturbances				
BURS vs. average distance to paved road	34	0.003	0.78	y = 0.0001 x + 0.2547
BURS vs. average distance to gravel road	19	0.3	0.02	y = 0.0021 x + 0.2646
BURS vs. average distance to dirt road	17	0.002	0.86	y = 0.0001 x + 0.2464
BURS vs. average distance to building	10	0.01	0.84	y = - 0.0001 x + 0.2409
BURS vs. average distance to powerline	8	0.01	0.87	y = 0.0002 x + 0.3075
BURS vs. average distance to roadsign	9	0.06	0.52	y = 0.0006 x + 0.2064
BURS vs. average distance to drill pad	22	0.2	0.04	y = - 0.0016 x + 0.4375
BURS vs. average distance to man-made mound/low perch	9	0.32	0.11	y = - 0.0013 x + 0.4125
Other				
Number of owl young vs. traffic rate and distance from nest to closest road	17	0.12	0.41	y = - 0.0052 rate + .0017 distance + 5.5062
Seasonal BURS (March-August) vs. traffic rate and distance from nest to closest road	36	0.12	0.12	y = -0.0006 rate + .0010 distance + .5686
Owl flushing distance vs. length of study period	216	0.02	0.03	y=-.0147 x + 39.9494
Owl flushing distance vs. ambient air temperature	193	0.007	0.26	y=.2788 x + 20.9765
Owl flushing distance vs. apron (soil) temperature	177	0.003	0.49	y=.174 x + 23.3579
Owl flushing distance vs. time of day	214	0.0208	0.04	y=-28.644 x + 46.3549

[a]BURS=Burrow use rate by burrow site (number of months site was active/number of months site was monitored)

[b] Significant p-value (<0.05) indicates slope of line is significantly different from zero

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Appendix J

Minimum Distance (m) to Selected Disturbances Measured Within a 2.2-kilometer Radius of Each Burrow Site. (Distances were averaged for sites with two or more burrow openings; blank cells indicate no data were taken; zero's indicate the burrow site is on the disturbance)

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Burrow Site Number	Dirt Road	Gravel Road	Paved Road	Building	Power Line	Power Pole	Pad	Man-made Mound/Low Perches
1			53.2				0	
2		7	59	17.5		172.5		
3		6		110.3		72.66		
4		160.4	78.2	176.4			166.4	
5	4.75	35.25					170.5	
6		143		190.5			110.5	40
7	28.66	7					128.7	
8		10.7						50.3
9	101.6		7.6					
10	5		16	152.5				
11			7.5					
12	2	110					0	60
13		59					80	106
14	59.33						43.66	
15		115			79		0	
16		4						
17	31.25		8	53.5	31.25		10.1	
18			59					
19			7	109				27
20	80		30					
21			9					190
22			228					
23			8		30			
24	18			28	24			
25	200	350		1000				
26	500	800		700				
27	132		117		217			
28	119							
29	265		377					295
30	15		159					
31	734	704	824					
32			50					0
33	238		287					
34	408							
35			105					75
36			300					
37			10					
38			9					
39			13					
40			5					
41	37.2	130					0	102.8
42			24					
43			35					40
44			148.7	181.3				

Burrow Site Number	Road sign	Crater Edge	Road Junction	Borrow Pit	Other Disturbance
1					
2					
3			92.3		
4					
5					170 to Active construction Fall 2001
6		26.5			
7					128 to Active construction Fall 2001
8					
9	20.3				
10					
11	85				
12					
13		25			
14					
15		120			
16	47		95		
17					33.5 to Beef Staging Entrance
18					
19			80		237 to Area 3 RWMS entrance
20					
21	16				
22					0 to ditch
23					
24					
25					
26					
27					
28				0	
29	385				
30					
31					
32					
33					
34					
35					84 to cable-line trenching
36					278 to cable-line trenching
37	163				
38				128	
39					
40					
41		129.7			
42					5 to cable-line trenching
43					139 to ditch
44					

Burrow Site Number	Dirt Road	Gravel Road	Paved Road	Building	Power Line	Power Pole	Pad	Man-made Mound/Low Perches
45			149				36	
46			6					
47			96	223	115			70
48			292	277				
49	6	13.5					339.5	290
50			330					
51	18.3		157.1	138.8			0	
52			48.7				0	
53			7.5				77.5	
54			2200				780	
55	395		533.3					
56								
57			350					
58		5					40	
59		8.5			93		102	
60	56.5		12.5					21.5 m
61	38							
62	115		169					
63	26.7	9.7	12.7				34.7	
64		205.7					0	
65	110		190					
66		8	94	85				
67			43.2				0	
68		7	110				57	
69		7						
70		80					0	
71	81		138					
72		350	600					
73		6					44	
74		5	270	20				
75	80						0	
76		5.7			180.3		25.7	
77		8				220	5	40
78			13					
79	10						40	

Burrow Site Number	Road sign	Crater Edge	Road Junction	Borrow Pit	Other Disturbance
45					
46					
47					
48					
49		170.5			
50					
51	111.8				162 to Sump U2GG bladed area
52				115	
53				20	
54					
55					
56					
57					
58					
59					
60					
61					
62					
63	22.7	133.7			
64					
65					
66					
67					
68	108				
69					
70					
71					
72					
73		162.5			
74					250 to RWMS Buildings
75		134		90	
76					
77					
78					
79					

Appendix K

Graphs of Ambient Air and Burrow Temperatures for Six Burrows (Burrow Site #15, #2, #14, #36, #13, and #30) from December 1997 to March 1998 and Six Burrows (#2, #41, #14, #36, #30, and #9) from December 1998 to March 1999.

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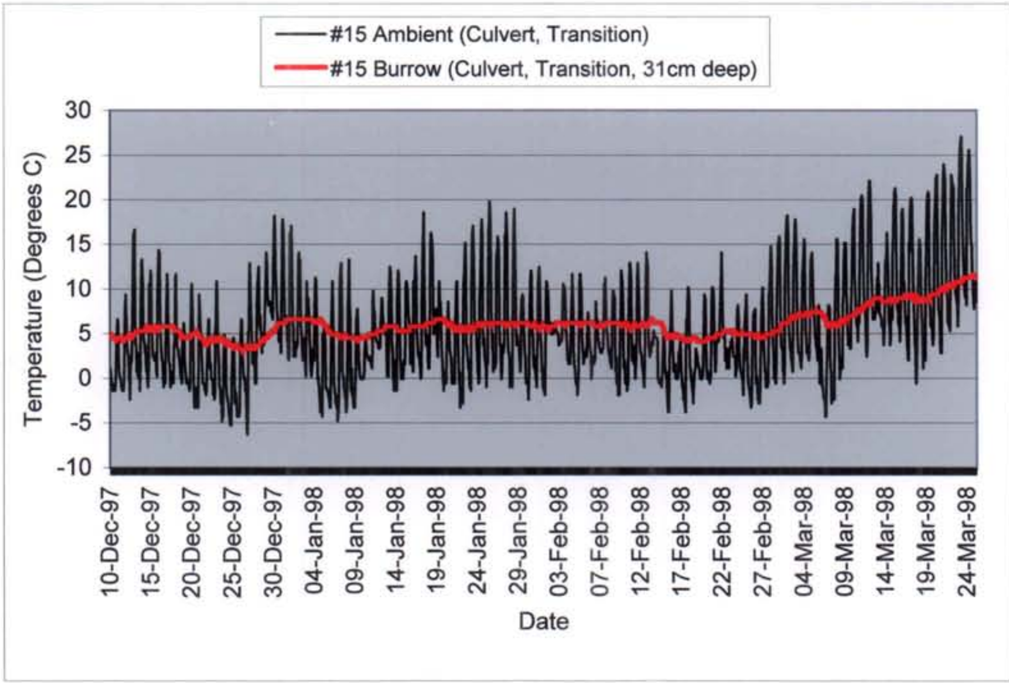
1997-1998



#15 Ambient (Culvert, Transition)
#15 Burrow (Culvert, Transition, 31cm deep)
Temperature (Degrees C)
30
25
20
15
10
5
0
-5
-10
10-Dec-97
15-Dec-97
20-Dec-97
25-Dec-97
30-Dec-97
04-Jan-98
09-Jan-98
14-Jan-98
19-Jan-98
24-Jan-98
29-Jan-98
03-Feb-98
07-Feb-98
12-Feb-98
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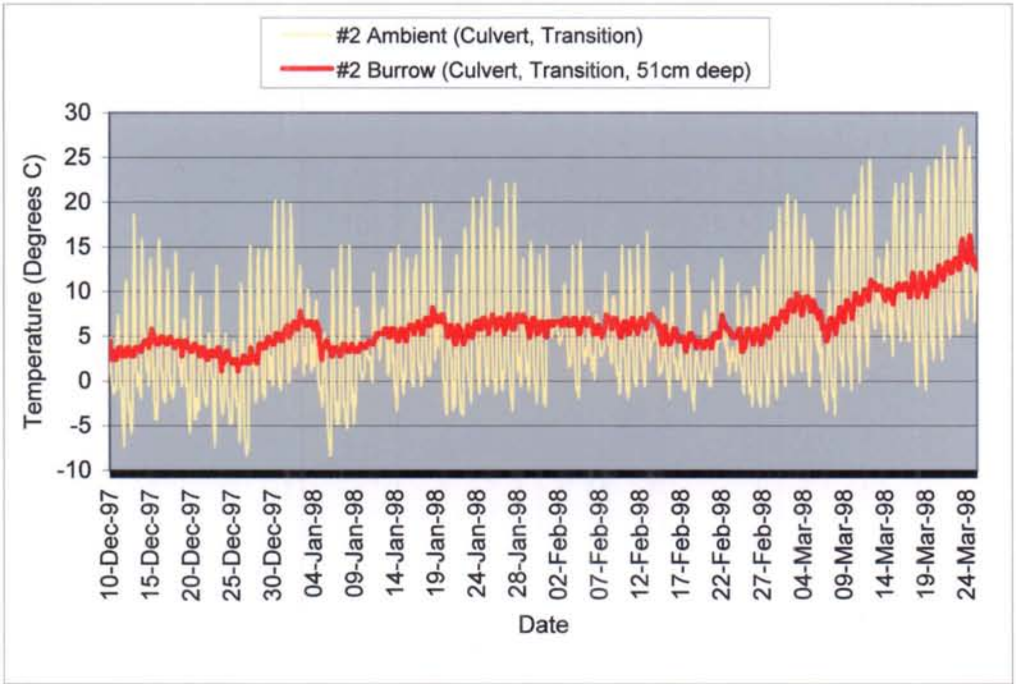
19-Mar-98
24-Mar-98
Date



#2 Ambient (Culvert, Transition)
#2 Burrow (Culvert, Transition, 51cm deep)
Temperature (Degrees C)
30
25
20
15
10
5
0
-5
-10
10-Dec-97
15-Dec-97
20-Dec-97
25-Dec-97
30-Dec-97
04-Jan-98
09-Jan-98
14-Jan-98
19-Jan-98
24-Jan-98
28-Jan-98
02-Feb-98
07-Feb-98
12-Feb-98
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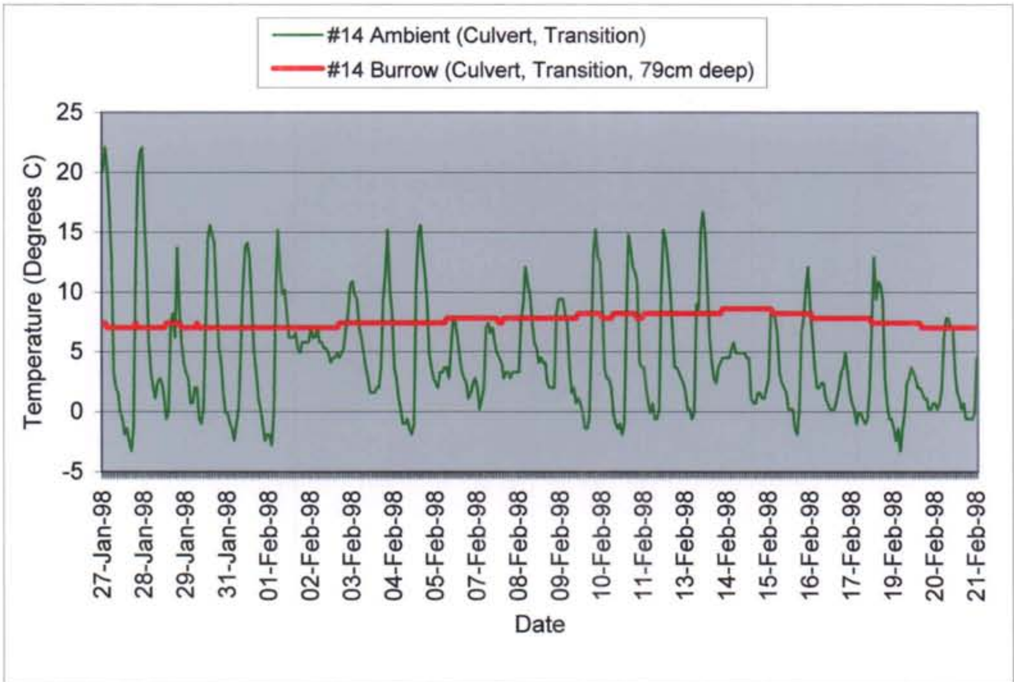
19-Mar-98
24-Mar-98
Date


#14 Ambient (Culvert, Transition)
#14 Burrow (Culvert, Transition, 79cm deep)
Temperature (Degrees C)
25
20
15
10
5
0
-5
27-Jan-98
28-Jan-98
29-Jan-98
31-Jan-98
01-Feb-98
02-Feb-98
03-Feb-98
04-Feb-98
05-Feb-98
07-Feb-98
08-Feb-98
09-Feb-98
10-Feb-98
11-Feb-98
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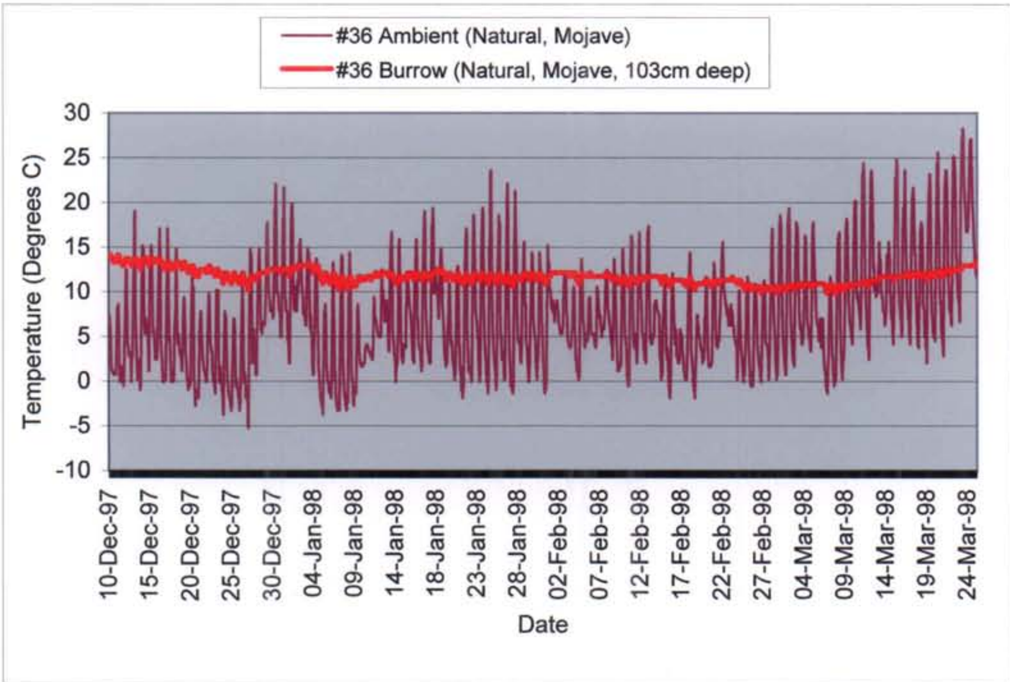
20-Feb-98
21-Feb-98
Date


#36 Ambient (Natural, Mojave)
#36 Burrow (Natural, Mojave, 103cm deep)
Temperature (Degrees C)
30
25
20
15
10
5
0
-5
-10
10-Dec-97
15-Dec-97
20-Dec-97
25-Dec-97
30-Dec-97
04-Jan-98
09-Jan-98
14-Jan-98
18-Jan-98
23-Jan-98
28-Jan-98
02-Feb-98
07-Feb-98
12-Feb-98
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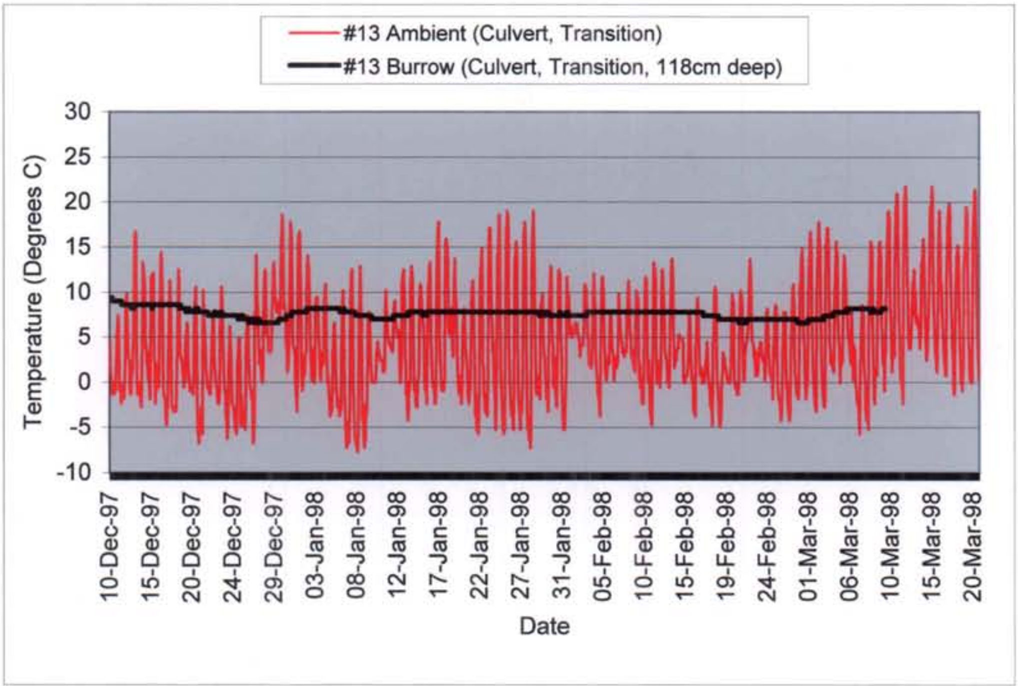
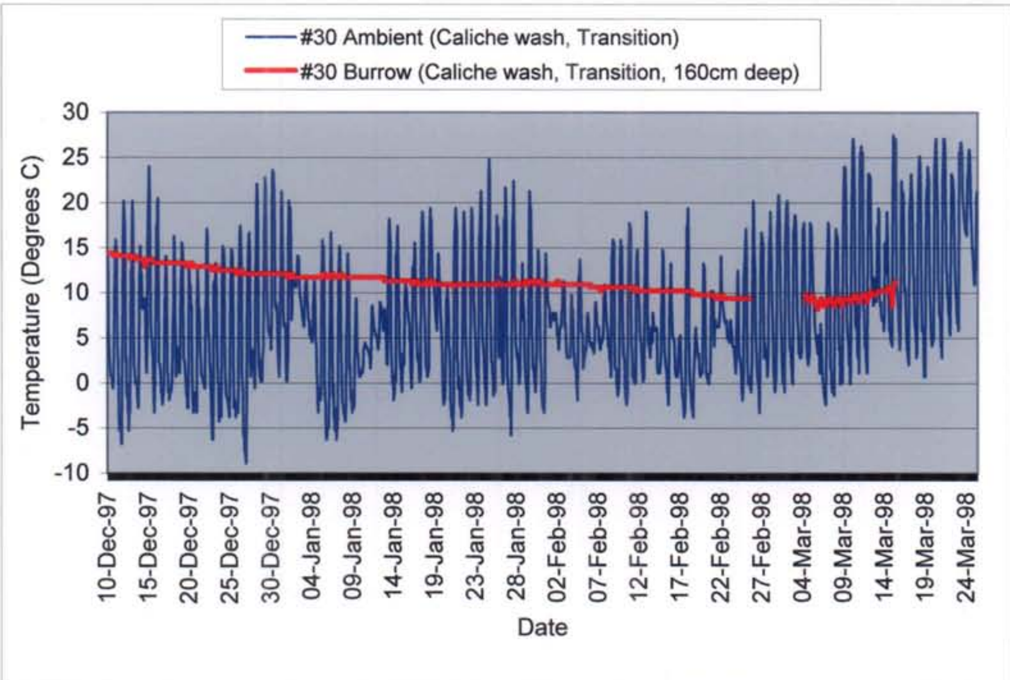
19-Mar-98
24-Mar-98
Date


#13 Ambient (Culvert, Transition)
#13 Burrow (Culvert, Transition, 118cm deep)
Temperature (Degrees C)
30
25
20
15
10
5
0
-5
-10
10-Dec-97
15-Dec-97
20-Dec-97
24-Dec-97
29-Dec-97
03-Jan-98
08-Jan-98
12-Jan-98
17-Jan-98
22-Jan-98
27-Jan-98
31-Jan-98
05-Feb-98
10-Feb-98
15-Feb-98
19-Feb-98
24-Feb-98
01-Mar-98
06-Mar-98
10-Mar-98
15-Mar-98
20-Mar-98
Date


#30 Ambient (Caliche wash, Transition)
#30 Burrow (Caliche wash, Transition, 160cm deep)
Temperature (Degrees C)
30
25
20
15
10
5
0
-5
-10
10-Dec-97
15-Dec-97
20-Dec-97
25-Dec-97
30-Dec-97
04-Jan-98
09-Jan-98
14-Jan-98
19-Jan-98
23-Jan-98
28-Jan-98
02-Feb-98
07-Feb-98
12-Feb-98
17-Feb-98
22-Feb-98
27-Feb-98
04-Mar-98
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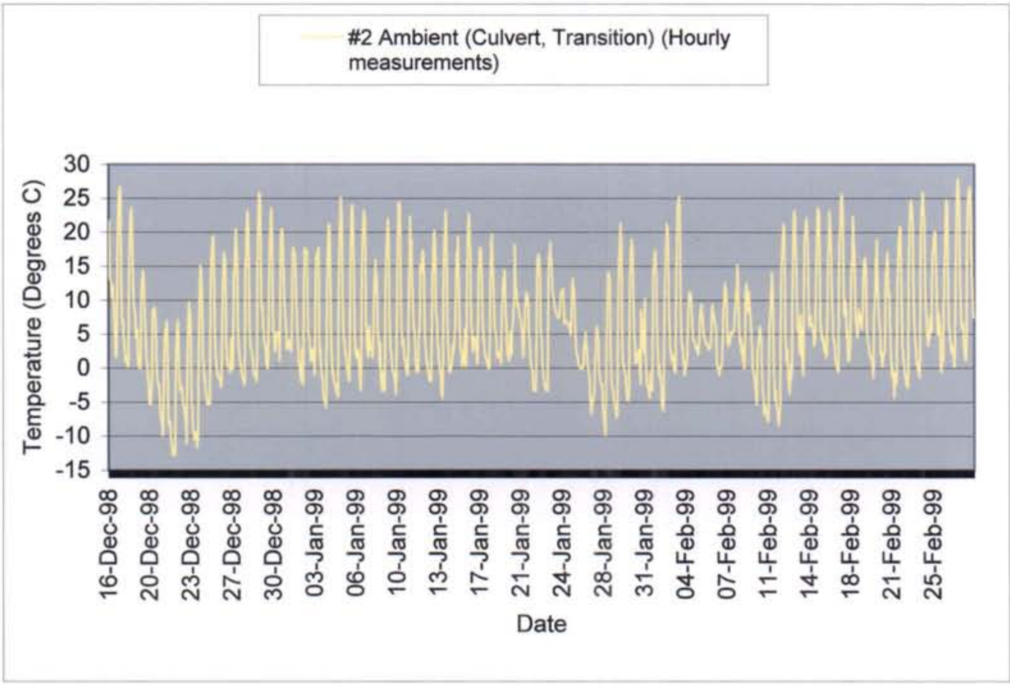
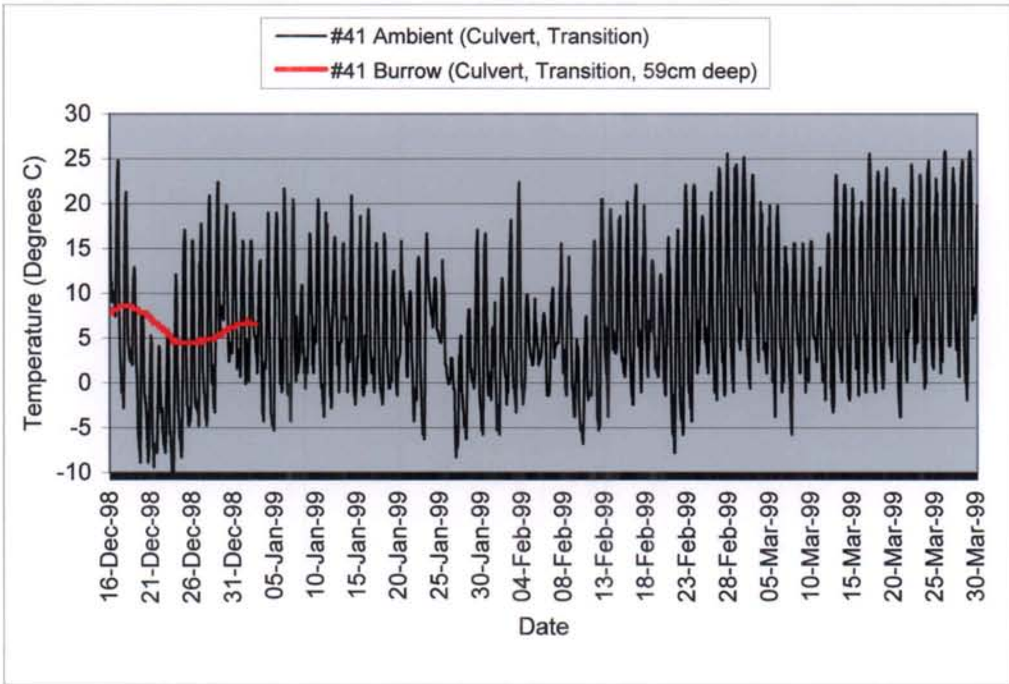
19-Mar-98
24-Mar-98
Date

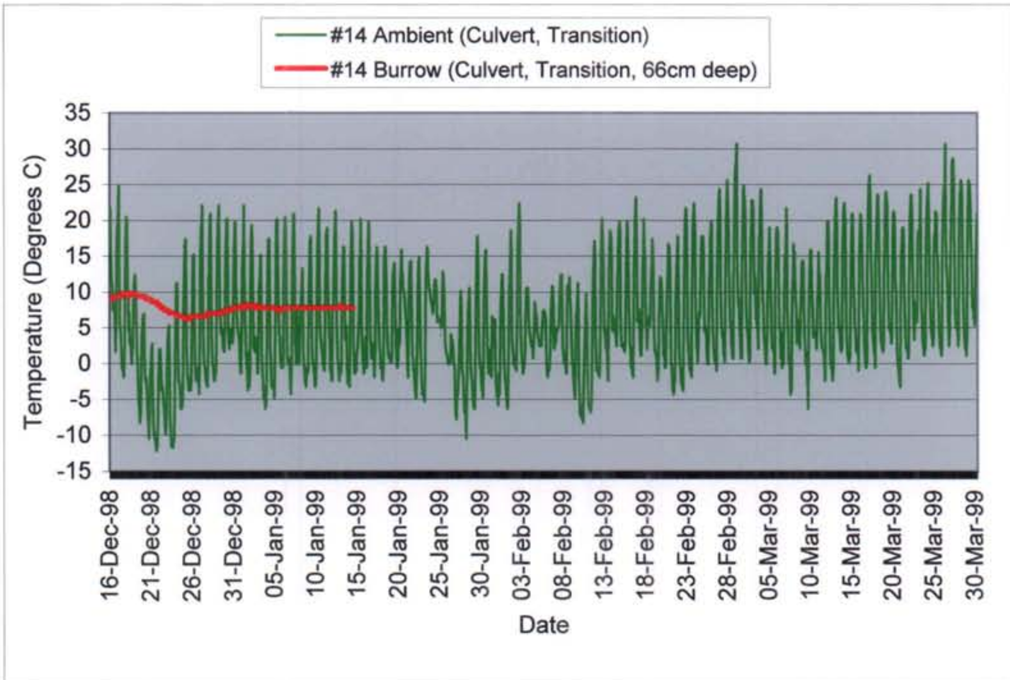
1998-1999



#2 Ambient (Culvert, Transition) (Hourly measurements)
Temperature (Degrees C)
30
25
20
15
10
5
0
-5
-10
-15
16-Dec-98
20-Dec-98
23-Dec-98
27-Dec-98
30-Dec-98
03-Jan-99
06-Jan-99
10-Jan-99
13-Jan-99
17-Jan-99
21-Jan-99
24-Jan-99
28-Jan-99
31-Jan-99
04-Feb-99
07-Feb-99
11-Feb-99
14-Feb-99
18-Feb-99
21-Feb-99
25-Feb-99
Date



#41 Ambient (Culvert, Transition)
#41 Burrow (Culvert, Transition, 59cm deep)
Temperature (Degrees C)
30
25
20
15
10
5
0
-5
-10
16-Dec-98
21-Dec-98
26-Dec-98
31-Dec-98
05-Jan-99
10-Jan-99
15-Jan-99
20-Jan-99
25-Jan-99
30-Jan-99
04-Feb-99
08-Feb-99
13-Feb-99
18-Feb-99
23-Feb-99
28-Feb-99
05-Mar-99
10-Mar-99
15-Mar-99
20-Mar-99
25-Mar-99
30-Mar-99
Date



#14 Ambient (Culvert, Transition)
#14 Burrow (Culvert, Transition, 66cm deep)
Temperature (Degrees C)
35
30
25
20
15
10
5
0
-5
-10
-15
16-Dec-98
21-Dec-98
26-Dec-98
31-Dec-98
05-Jan-99
10-Jan-99
15-Jan-99
20-Jan-99
25-Jan-99
30-Jan-99
03-Feb-99
08-Feb-99
13-Feb-99
18-Feb-99
23-Feb-99
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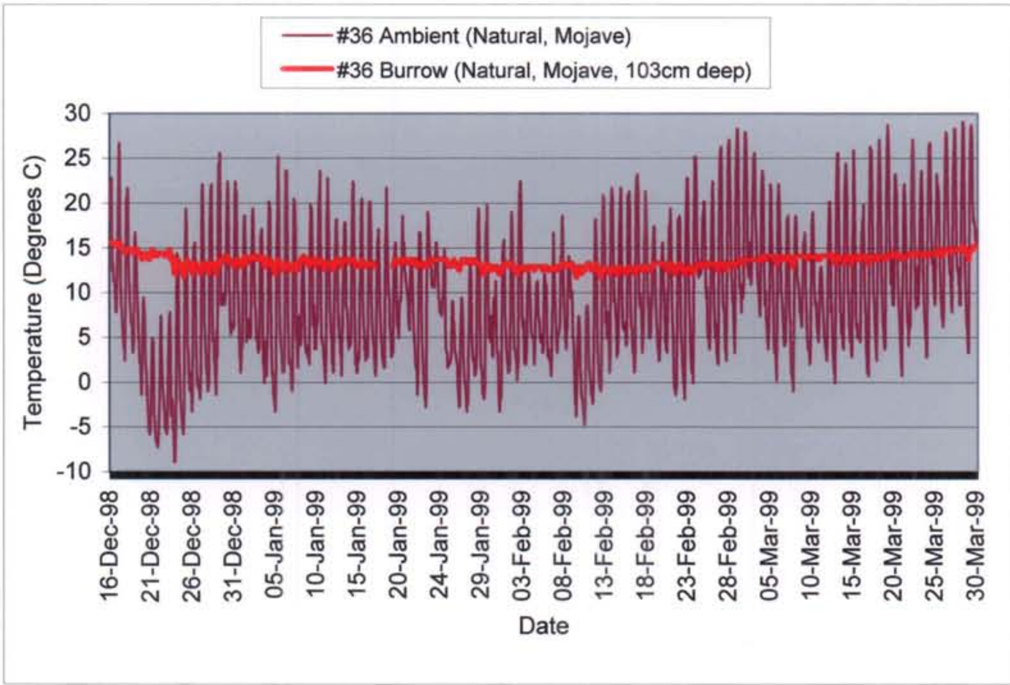
05-Mar-99
10-Mar-99
15-Mar-99
20-Mar-99
25-Mar-99
30-Mar-99
Date



#36 Ambient (Natural, Mojave)
#36 Burrow (Natural, Mojave, 103cm deep)
Temperature (Degrees C)
30
25
20
15
10
5
0
-5
-10
16-Dec-98
21-Dec-98
26-Dec-98
31-Dec-98
05-Jan-99
10-Jan-99
15-Jan-99
20-Jan-99
24-Jan-99
29-Jan-99
03-Feb-99
08-Feb-99
13-Feb-99
18-Feb-99
23-Feb-99
28-Feb-99
05-Mar-99
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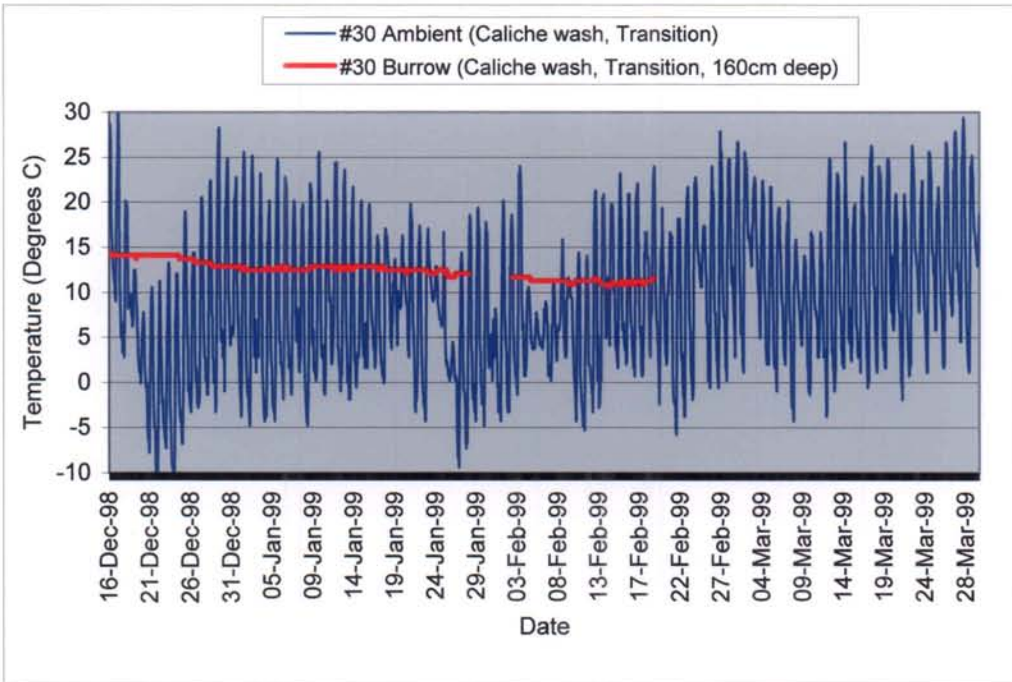
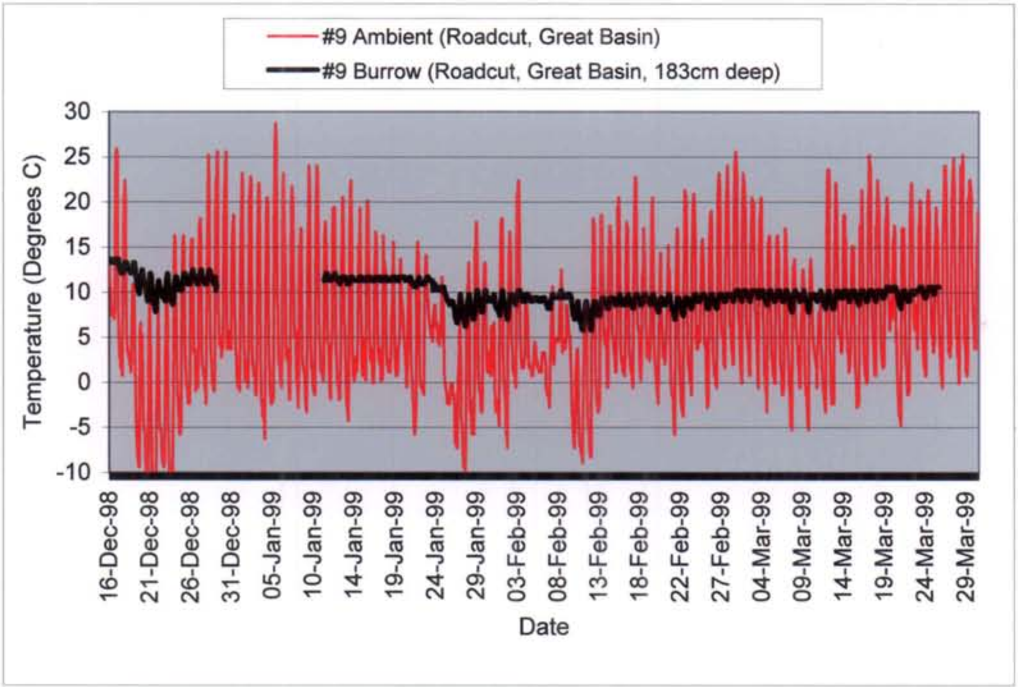
15-Mar-99
20-Mar-99
25-Mar-99
30-Mar-99
Date


#30 Ambient (Caliche wash, Transition)
#30 Burrow (Caliche wash, Transition, 160cm deep)
Temperature (Degrees C)
30
25
20
15
10
5
0
-5
-10
16-Dec-98
21-Dec-98
26-Dec-98
31-Dec-98
05-Jan-99
09-Jan-99
14-Jan-99
19-Jan-99
24-Jan-99
29-Jan-99
03-Feb-99
08-Feb-99
13-Feb-99
17-Feb-99
22-Feb-99
27-Feb-99
04-Mar-99
09-Mar-99
14-Mar-99
19-Mar-99
24-Mar-99
28-Mar-99
Date


#9 Ambient (Roadcut, Great Basin)
#9 Burrow (Roadcut, Great Basin, 183cm deep)
Temperature (Degrees C)
30
25
20
15
10
5
0
-5
-10
16-Dec-98
21-Dec-98
26-Dec-98
31-Dec-98
05-Jan-99
10-Jan-99
14-Jan-99
19-Jan-99
24-Jan-99
29-Jan-99
03-Feb-99
08-Feb-99
13-Feb-99
18-Feb-99
22-Feb-99
27-Feb-99
04-Mar-99
09-Mar-99
14-Mar-99
19-Mar-99
24-Mar-99
29-Mar-99
Date

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