National Survey of Historic Sites and Buildings

"SCIENCE AND INVENTION"

Theme XX d

Consolidated Report
on
Sites in Southwest Region

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INTRODUCTION

The Southwest was essentially a frontier environment throughout the period covered by this study. Thus one looks in vain for fundamental accomplishments in such pure sciences as physics and chemistry. Laboratory facilities of the type that would result in such accomplishments were nonexistent. The same sorts of environmental limitations apply to the field of invention, though there were some notable applications of inventions that had been developed in the East.

Very significant scientific work was done, however, in two fields: anthropology and the natural sciences--primarily biology and geology. Anthropology (including its subdisciplines--archeology, ethnology, linguistics, etc.), is not treated in this study, it being the opinion of this Region that this broad field should be incorporated into a special theme study dealing with the social sciences.

Thus we come to the crux of this discussion: the natural sciences. We may conceive of the Southwest as a great open book exhibiting some of nature's most stupendous wonders, some of its most fantastic geologic manifestations, some of its most variegated landscapes and life zones. As the Southwest was culturally a raw and extreme land, so was it raw and extreme in nature. From the time of the first Spaniard right up to the present day the scientist has found nature exposed here, naked to the elements. In the deserts, in the mountains rising abruptly from the deserts, and in the canyons gashing the deserts, the scientist found incredible conjunctions in geology and biology. In a few hours he could hike from Sonoran desert to Alpine forest in Southwestern mountains, or descend through two billion years of earth history in Grand Canyon. Thus, in natural science, as in art and literature, the Southwest was the Nation's great outdoor laboratory and place of inspiration. Here came the savants of the East to gather objects and impressions which they took back East to their laboratories. For most of the period here considered, the basic approach to the Southwestern frontier in science, as in every other field, was extractive.

The history of science in the pre-1915 Southwest falls into two distinct, though overlapping, stages:

(1) The era of the field men who collected and classified;

(2) the era of the theorizers who systematized and synthesized. In general, it may be said that finding sites to associate with the first era is difficult, for most of this work was accomplished by scientists accompanying government and military surveys and explorations.

The groups conducting these expeditions were "passing through" and did not pause anywhere long enough to establish geographic points of special significance. There are a few sites, however, associated with the second era, as well as some that do not fit neatly into either category.

Development of the atomic bomb during World War II opened the door to the present Nuclear Age. The latter-day Prometheans of the Manhattan Project gave the fire of the universe to mankind, with all its potentials for good or evil. The transcendent significance of this scientific achievement justifies waiver of the 50-year criterion, making possible consideration of the Trinity and Los Alamos sites.

The material that follows, including site descriptions and evaluations of the work of particular outstanding scientists for whom it would be desirable to find site associations, is based on field work, documentary research, and consultation with the following authorities: Matt Dodge, former Regional Naturalist in this Office; Dr. William B. McDougal and Dr. Ardith Johnsen of the Museum of Northern Arizona; Dr. C. P. Oliver, Chairman of the Zoology Department of the University of Texas; Chief Astronomer Henry Giclas of Lowell Observatory; and staff members of the Desert Laboratory in Tucson.

William E. Brown
Regional Historian

WORKING LIST OF SITES

UNITS OF THE NATIONAL PARK SYSTEM

1. Grand Canyon National Park, Arizona
   Glen Canyon National Recreation Area, Arizona-Utah
   Canyonlands National Park, Utah
   Capitol Reef National Monument, Utah

2. Tumacacori National Monument, Arizona

3. Carlsbad Caverns National Park, New Mexico

4. Big Bend National Park, Texas

PROPOSED UNIT OF THE NATIONAL PARK SYSTEM

1. Chamizal International Memorial, Texas

SITES OF EXCEPTIONAL VALUE

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2. Desert Laboratory, Arizona

3. Lowell Observatory, Arizona

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SITES ALSO CONSIDERED

1. Fort Whipple, Arizona

2. Camp Verde, Arizona

3. Meteor Crater, Arizona

4. Fort Wingate, New Mexico

5. Los Alamos Scientific Laboratory, New Mexico

6. Fremont Campsite, Utah

UNITS OF THE NATIONAL PARK SYSTEM

1. Grand Canyon National Park, Arizona
Glen Canyon National Recreation Area, Arizona-Utah
Canyonlands National Park, Utah
Capitol Reef National Monument, Utah

The post-Civil War years inaugurated a new scientific era in the Southwest. The period of reconnaissance and discovery was largely replaced by one of research in depth and the beginnings of theoretical generalization--a trend that continued to gain momentum throughout the period under study.

Four geological and geographical surveys, later called the Great Surveys, undertook the massive task of finding out what lay west of the hundredth meridian. Parties led by Ferdinand Vandiveer Hayden, medical doctor turned geologist, Clarence King, aristocrat and intellectual, John Wesley Powell, conqueror of the Colorado River, and Lt. George M. Wheeler, determined military man and scientist, roamed over the wild country during the years 1867-79, observing, analyzing, theorizing, mapping, and, at the end of each season, returning to Washington to publish their results. The inquiries of the Great Surveys into geology, geography, and biology formed the basis for much of the knowledge of the physical West. Their scientific contributions were enormous, most of them published in some 120 major volumes listed in the Checklist of United States Public Documents, 1787-1901. In 1879 the Great Surveys were consolidated into the United States Geological Survey and the great work continued throughout the period of this study and down to the present day.

In terms of scientific achievement in Southwest Region, the giants of the Great Surveys and the subsequent U. S. Geological Survey were John Wesley Powell, Othniel C. Marsh, Grove Karl Gilbert, W. M. Davis, and C. E. Dutton.

Powell, explorer of the Colorado River and writer of a classic adventure story based on that exploration, is usually dismissed in just those words. But as Bernard DeVoto has pointed out in his introduction to Wallace Stegner's Beyond the Hundredth Meridian, Powell was a great scientist who used his knowledge to pierce through romantic misconceptions about the West and propose a realistic program for its development. Powell's Report on the Lands of the Arid Region of the United States is the first great scientific synthesis on the West. Here he used the methods and data of science to evolve an encompassing theory that would shape legal, political, and social institutions in a West dominated by the fact of aridity. Even if Powell had not been the prophet of the West, his work as geologist and ethnologist would have made him a great scientist. His founding of two of the most influential scientific government bureaus would have made him a great man.

Even though Powell's later activities were of much greater national importance, his river journey down the Colorado was, as Stegner puts it, symptom and symbol. Here he began the scientific approach to the West that would result in such momentous contributions. Canyonlands National Park, Grand Canyon National Park, and Glen Canyon National Recreation Area are suited to commemoration of Powell's career.

Othniel C. Marsh, one of the greatest American paleontologists, President of the National Academy of Sciences, is chiefly remembered for his developmental history of the horse from Eohippus to Equus, the clinching documentation of the theory of evolution. His work in association with the Great Surveys and the U.S. Geological Survey was instrumental in fixing the geologic ages and tracing the story of plant and animal life in the West.

Marsh's work is commemorated by Marsh Peak in the Uinta Mountains of Utah where he did some of his most important field investigations, but no suitable historic site is known at the time of this writing.

Grove Karl Gilbert's contributions to geology were of the same magnitude as Powell's. His brilliant theoretical mind and vivid imagination found its challenge in the questions raised by the geology of the Great Basin and the plateaus of Utah. Many of his theories have continued to be considered valid in the light of half a century of additional research.

Though he worked for 4 years with the Wheeler Survey, Gilbert's most important contributions date from his association with Powell, both in the Powell Survey and later with the U. S. Geological Survey. His "Report on the Geology of the Henry Mountains" (Powell Survey, 1877) developed the Laccolithic Theory, a major step forward in the understanding of volcanism. His "Lake Bonneville" (U. S. Geological Survey, 1890) was the definitive monograph on that subject. Gilbert, along with W. M. Davis, was largely responsible for the creation of the

subscience, physiography, which deals with the earth's surface and the processes by which it is being changed.

Gilbert's base camp in the Henry Mountains of Utah would be an excellent site to commemorate his work. Known as Cache Camp or Camp No. 1, the site is near Dugout Creek where that stream leaves the western slopes of Mt. Ellen. The McMillen Springs Campground of the Bureau of Land Management, which controls the entire Henry Range, is near the site and an interpretive exhibit could be developed there. The Henry Mountains themselves--the type-site laccoliths--should be considered eventually in the Natural Landmarks program.

Meanwhile, Gilbert's strong associations with Capitol Reef and Canyonlands should be exploited in the interpretive programs at these areas.

Capt. Clarence E. Dutton was another Powell protégé who made his geological mark while associated with the Powell Survey and the U.S. Geological Survey. His Report on the Geology of the High Plateaus of Utah (Powell Survey, 1880) and his Tertiary History of the Grand Canyon District (U.S. Geological Survey, 1882) have ever since been scientific classics and established Dutton for all time as one of America's great geologists.

Grand Canyon National Park is the obvious commemorative site.

W. M. Davis ranks with Powell and Gilbert in the development of the science of physiography. Building upon the work of his predecessors, he added new principles to the science, outlined the theory

of progressive stages in the development of land forms, and gave the science organization and definition. His Physical Geography, 1890, and Geographical Essays, 1909, are his most famous works. However, his extensive field work in the Grand Canyon and a number of basic monographs derived therefrom were instrumental in the development of his physiographic theories.

Grand Canyon National Park is again the suitable commemorative site.

2. Tumacacori National Monument, Arizona

Spanish expeditions into the Southwest were accompanied by scientists or naturalists who reported on the geography and the flora and fauna of the zones through which they passed. Thus Coronado's expedition reported the Grand Canyon and the buffalo. But these early observers made no notable contributions to theoretical science, nor did they often rise above the level of sheer wonderment at their discoveries.

With the coming of the Jesuits into southern Arizona a more systematic and profound scientific spirit was exhibited. Foremost among these missionaries was Father Eusebio Francisco Kino. His work as cartographer and geographer of Pimería Alta, as well as his descriptive writings, are still basic sources for naturalists, historians, and anthropologists concerned with this region. Being a man of many parts Kino does not fit neatly into any particular scientific niche, but he can well be termed the first scientist of the Southwest. Tumacacori National Monument is the commemorative site.

Perhaps the finest systematic scientific treatise rendered by a Jesuit missionary was Father Ignaz Pfefferkorn's Description of the Province of Sonora. The first volume of this work is a detailed catalogue of the animal, plant, and mineral kingdoms in the region traversed by Pfefferkorn in his missionary travels. Though his longest assignments were at the missions of Atí and Cucurpe in what is now Sonora, Mexico, Pfefferkorn was also stationed at mission San Gabriel de Guebavi in Arizona at the junction of the Sonoita and Santa Cruz Rivers. Mission Tumacacori was one of Pfefferkorn's visitas at this time. His natural history of Sonora encompasses the entire geographic province up to the Gila River and is far and away the most significant work of its kind during the Spanish Period. Pfefferkorn's study of Sonoran natural phenomena is more than a historical curiosity. Today's naturalists find it an invaluable source for tracing the evolution of the Sonoran desert from the mid-18th century to the present.

The best site in the United States for commemorating Pfefferkorn's work is Tumacacori National Monument.

5. Carlsbad Caverns National Park, New Mexico

Vernon Orlando Bailey, protégé and son-in-law of C. Hart Merriam (see below), was Chief Naturalist of the Bureau of Biological Survey. In the field of mammology especially, he brought to fruition Merriam's Life Zone concept. His studies in New Mexico were very significant, resulting in a shelf of official Biological Survey reports. Florence Merriam Bailey, Vernon's wife, warrants the title of greatest American

woman ornithologist. Though many of the publications of this husband-and-wife team date from the 1920s, the field work upon which these publications were based began in the 1890s. One of their favorite field locations was the Carlsbad-Guadalupe Mountains area of New Mexico and Texas. Vernon Bailey's Animal Life of Carlsbad Cavern is perhaps his finest ecological study.

Carlsbad Caverns National Park is the best site to commemorate the Baileys' work.

4. Big Bend National Park, Texas

According to Professor C. P. Oliver of the University of Texas, the most important Texas scientist within the period of this study was Dr. William Morton Wheeler. As Professor of Zoology at the University of Texas, Dr. Wheeler performed fundamental research in entomology, particularly in his studies of ants. He was later associated with Eastern universities and became a member of the National Academy. As related by Dr. Oliver, Wheeler's published studies are basic works in the science of entomology.

Other important work was done in Texas in the fields of geology and biology, but, with the exception of Wheeler, particular scientists have not been evaluated at this writing. One site, however, can be listed: Big Bend National Park. According to Dr. Oliver, the Big Bend country was the great outdoor laboratory of Texas scientists, in much the same way that the Grand Canyon served scientists farther west. At Big Bend are found the same sorts of startling geologic and biologic

conjunctions. Since the turn of the century, this region has attracted many scientific expeditions which have attempted to unravel its complex geology and varied ecological patterns.

PROPOSED UNIT OF THE NATIONAL PARK SYSTEM

Chamizal International Memorial, Texas

The Boundary Survey that fixed the line between Mexico and the United States in the early 1850s resulted in significant contributions in the fields of geography, geology, and biology. The most important document relating to the subject is Emory's Report on the United States and Mexican Boundary Survey (Washington, 1859), which includes two volumes of scientific reports. In addition to the geographic and cartographic activities of the Topographical Engineers who conducted the survey, accompanying field scientists described the geology of the boundary region and collected many biologic specimens. These field reports and collections became the tools of Eastern scientists, who for the first time had adequate material to begin generalizing and theorizing about the Southwest. The region's geologic history was reconstructed. Doctor Parry and Arthur Schott advanced theories of mountain-making, continental uplift, igneous intrusion and inundation. Paleontologist James Hall correlated strata formations and began geologic mapping. Botanists John Torrey and George Englemann, basing their work on the Boundary Survey collections, produced monumental works on plant classification. Zoologists Baird and Girard of the Smithsonian Institution made similar contributions in their discipline. These various scientific labors, especially in the field of geology, resulted in the first groping attempts to assign principles of scientific causality

to the natural history of the Trans-Mississippi West. Thus the scientific significance of the Boundary Survey can hardly be exaggerated.

The proposed Chamizal International Memorial at El Paso, Texas, would be an ideal site at which to commemorate the scientific work of the Boundary Survey.

SITES OF EXCEPTIONAL VALUE

1. C. Hart Merriam Base Camp, Arizona

Location: Coconino County, at Little Spring private enclave in Coconino National Forest.

Ownership and Administration: On C.O. Bar Livestock Co. land; owned by Mr. John Babbitt, Babbitt's Dept. Store, Flagstaff, Arizona.

Significance: As in geology, so in biology, the last years of the 19th century brought to the fore a distinguished group of synthesizers in the Southwest. Most important of these was the great zoologist Dr. C. Hart Merriam, America's first bio-ecologist, who established the Life Zone concept in 1889 in the San Francisco Mountains of Arizona. Merriam had accompanied the Hayden Survey in 1872, and was the founder and first chief of the U.S. Bureau of Biological Survey, predecessor of the present Fish and Wildlife Service.

Though hints of zonal distribution of plant and animal life had been dropped as early as the time of Humboldt, Merriam was the first to advance and define the Life Zone concept in scientific terms. In his report on the San Francisco Mountain region (1890) he graphically recorded his conclusions--that forms of life are peculiar to given altitudinal areas or zones, hence the designation of a region or zone by the presence of flora and fauna not found in others. Since temperatures on north slopes differ from those on south exposures, life zones do not run on arbitrary contours. Latitude is also important in determining climate. This combination of altitude, exposure, and latitude

(climate) is basic in the ecology that governs the existing distribution of flora and fauna indigenous to the various regions. Merriam's concept was fundamental in the development of the science of ecology--the most important modern generalization in the biological field.

As America's first bio-ecologist, Merriam ranks in the top bracket of American scientists. His study of the San Francisco Mountains biota was the first correlation of both plants and animals. His "laws of temperature" delimiting life zones and life distribution were fundamental to the Life Zone concept. It is true that Merriam over-generalized and made mistakes. But his work was germinal to the development of the modern science of ecology. He was a catalyst who opened the gates on what has proved to be the most fruitful line of approach in modern biological science. Not only were his correct deductions and generalizations useful, but in the very process of disproving his errors, other scientists were stimulated to make fundamentally important contributions. All ecologists and zoologists know and refer to Merriam's work, and his report on the San Francisco Mountains continues to be cited as the pioneer model for bioecological studies. One noted commentator on the life sciences, S. Charles Kendeigh, after discounting Merriam's errors, stressed the fundamental provocative nature of his work and the continuing basic use of the life zone tool, locally and regionally, wherever ecological studies are in progress.

In the itinerary section of his report on the San Francisco Mountains, Merriam states:

> After spending three days in outfitting [at Flagstaff], we proceeded to Little Spring, at the north base of San Francisco Mountain, and pitched our tents in a grove of aspens and pines, on a knoll just northwest of the spring, at an altitude of 2,500 meters (8,250 feet). This was our base camp for two months [August and September 1889], and from it numerous side-trips were made into the surrounding country.

Present Status: Today Little Spring is in a private enclave within the boundary of Coconino National Forest. The land is part of the C.O. Bar Livestock Co. of Flagstaff. As shown by the attached photos the site retains complete integrity. The spring cove is on a slope that opens upon a beautiful meadow. Wildlife and handsome trees, including very large aspens, give the scene a pristine quality that recalls its charm for a biological investigator. Little Spring is easily reached by a good Forest Service road, which branches off of U.S. 180. It is located in T23N, R6E, 20 miles northwest of Flagstaff.

References: C. Hart Merriam, Results of a Biological Survey of the San Francisco Mountain Region . . . U.S.D.A., Division of Ornithology and Mammalogy. North American Fauna Series #3 (Washington, 1890); Rexford F. Daubenmire, "Merriam's Life Zones of North America," Quarterly Review of Biology, XIII (Sept. 1938); S. Charles Kendeigh, "History and Evaluation of Various Concepts of Plant and Animal Communities in North America," Ecology, XXXV (April 1954).

2. Desert Laboratory, Arizona

Location: Pima County, just west of Tucson on Tumamoc Hill.

Ownership and Administration: Dr. Terah L. Smiley, Director, Geochronology Laboratories, University of Arizona, Tucson.

Significance: The Desert Laboratory of the Carnegie Institution of Washington opened in 1903 at Tucson, Arizona. For nearly half a century it was the center for the study of North American desert ecology. Notable among the distinguished scientists who made the Desert Laboratory a world-famous institution were Dr. D. T. MacDougal and Dr. Forrest L. Shreve. MacDougal's association with the Laboratory began in 1903; Shreve's in 1909. These men and their associates established the scientific foundations for the ecology of arid regions. Most important were their reports on the role of arid conditions in the evolution of flora and the migration of plants from humid zones. These early studies covered not only the Southwest and northern Mexico, but expeditions sponsored by the Desert Laboratory conducted field experiments and observations in Australia, Asia Minor, Egypt, Sudan, Libyan Desert, Algeria, and South Africa. These various research projects of the Desert Laboratory concentrated on desert vegetation, with special attention to the morphology and physiology of the spinose and succulent types which inhabit arid regions, their adjustments to arid conditions, distributional movements, and the phytogeography of deserts in general. Scores of major publications by the Carnegie Institution and hundreds of articles contributed to transactions of societies and to periodicals

resulted from the researches at the Desert Laboratory. These contributions were instrumental in establishing the scientific bases for desert ecology, not only in the United States but throughout the world.

Present Status: The site encompasses some 800 acres on Tumamoc Hill, or "Science Hill," just west of Tucson. Three major buildings date from the historic period: Main Laboratory (original wing, 1903; main wing, 1906); Buildings No. 2 and 3 (1906). These buildings and a number of more recent structures are used as laboratories in the geochronology program of the University of Arizona. The purpose of the current program is to advance knowledge of geologic time, of past climates, and of evolution of terrestrial biotas. Thus there is a direct line of continuity in the scientific work at the site. The Desert Laboratory was founded in 1903. Its operations ceased in the late 1930s and the area was transferred to the U.S. Forest Service in 1940 for use as an experiment station. In 1958 it became a unit of the University of Arizona. The grounds surrounding the laboratory are fenced to protect the many type specimens identified by the early botanists of the Carnegie Institution.

References: Annual Reports of the Carnegie Institution, 1903 et. seq.; Historical Files of the Desert Laboratory (in library of the University of Arizona); Forrest Shreve and Ira L. Wiggins, Vegetation and Flora of the Sonoran Desert (Stanford, 1964), introduction contains history and evaluation of significance of Desert Laboratory.

3. Lowell Observatory, Arizona

Location: Coconino County, on Mars Hill 1 mile west of Flagstaff.

Ownership and Administration: Dr. John Scoville Hall, Director, Lowell Observatory, Flagstaff.

Significance: Lowell Observatory was founded in 1894 by Dr. Percival Lowell. Within the period of this study, this observatory was the one significant center of "pure" science in the Southwest Region. The observatory is noted for intensive studies of Mars (in connection with which Dr. Lowell advanced the theory that the planet was inhabited by intelligent beings); the discovery of Pluto; and Dr. Andrew Elliott Douglass' researches into zodiacal light and sunspot phenomena. In connection with this latter work, Dr. Douglass discovered dendrochronology, most often associated with archeology, but probably more fundamentally important in climatology. Most important, however, is the fact that beginning in 1912 Dr. V. M. Slipher of the Lowell Observatory discovered the first observational evidence of the expanding universe. This was a cosmological discovery of the first magnitude, ranking in the history of astronomy with the Copernican Revolution. On the basis of this discovery alone, the Lowell Observatory must be considered one of the world's most important astronomical centers.

Lowell Observatory stands on Mars Hill overlooking Flagstaff. It continues, in the tradition established by Dr. Lowell, in pursuing a broad program of astronomical research. Lowell established the observatory primarily for the purpose of studying the solar system and its

evolution, and established the pioneering approach to planetary astronomy. The Planetary Library and Research Center of the observatory, and its status as the world center for planetary photography, are symbolic of the continuity of Lowell's original purpose.

Present Status: Of the historical structures at the site, the most important is the original 1896 housing for the historic 24-inch Lowell Refracting Telescope. This instrument, installed in 1896, has been in continuous operation since that time. The original library and administration building, built in 1894, is now a residence, but retains its exterior historical character. The present administration building dates from 1914. The overall integrity of the site is high, both as to surviving historic structures and the continuing use of the observatory. Lowell Observatory is a privately endowed scientific institution administered by the Percival Lowell Estate.

References: Interview with Chief Astronomer Henry Giclas, 9/15/64; "The Lowell Observatory", 6-page folder issued at the observatory; "Notes and Professional Reports" of V. M. Slipher, Lowell Observatory Library; Jack L. Cross, et al., Arizona, Its People and Resources (Tucson, 1960); Percival Lowell, Observations on the Planet Mars . . . (Flagstaff, 1894-95, 1898).

4. Trinity Site, New Mexico

Location: Socorro County, some 25 miles south of U.S. 380 on the White Sands Missile Range.

Ownership and Administration: The White Sands Missile Range is a restricted Army installation; the Trinity Site is on land owned by the Dept. of Defense.

Significance: There is little need to expound upon the significance of the explosion of the world's first nuclear device at this site on July 16, 1945. An excellent account of the scientific research and development that lay behind the first atomic bomb test, as well as a narrative of events at the test site itself, is contained in the attached 20th Anniversary issue of The Atom (LASL, July 16, 1965). Dr. Richard Hewlett, Chief Historian of the Atomic Energy Commission, gives the Trinity Site first place in his listing of five sites recommended by the AEC's Historical Advisory Committee for Landmark status.

Present Status: The Ground Zero area at the Trinity Site is enclosed by a cyclone fence about a mile in circumference. Within this fence are: (1) the lava-stone monument recently erected by the Army at Ground Zero; (2) the fused, eroded stumps of three of the four concrete piers that supported the steel tower on which the bomb was detonated (the other pier was vaporized, though remnants of its stump may be buried); (3) scattered particles of trinitite, remains of the 800-yard-radius shield of sand fused into glass by the bomb; (4) mounds of sand covering the remains of three 6' by 12' concrete-covered

instrument bunkers at the west, north, and southeast extremities of the fenced area; and (5) the almost indiscernable saucer-like crater scooped out by the bomb, but since then blurred into its surroundings by wind drift.

Outside the fenced area are three concrete camera bunkers--two about 1 mile due north of Ground Zero, one about a mile westerly. Also west 800 feet from Ground Zero are the remains of the 214-ton Jumbo container and the twisted steel girders of its support tower. This great steel vessel was designed to contain the explosion, and--in case of test failure--to hold for recovery the active plutonium. But it was never used, and though the tower was destroyed, Jumbo survived the explosion unscathed.

Only the sites are left of the three command bunkers that were 10,000 yards south, west, and north of Ground Zero. Army authorities destroyed them within the last 2 or 3 months because the wooden supports of the heavy concrete protective shields were rotting, threatening collapse, and because rattlesnakes were denning in them. One of these bunkers was Station South 10,000, the control center for the test where J. Robert Oppenheimer, director of the atomic bomb project, Maj. Gen. Leslie R. Groves, overall director of the Manhattan Project, and Kenneth Bainbridge, test director, listened to the countdown and first saw the awful product of their work.

Except for miscellaneous remnants of equipment, power and telephone lines, etc., associated with the test, the only other significant site

is the McDonald Ranch complex. The ranch house was used for final assembly of the active material for the bomb. Reportedly, it still stands some 10-15 miles southeast of Ground Zero. The writer was unable to visit it.

Because the White Sands Missile Range is a restricted area under heavy security guard, and because the Trinity Site is deep within the range--practically speaking, inaccessible--this tremendously important site has deteriorated badly. The Army's destruction of the three command bunkers, understandable as a safety measure, is an irreparable catastrophe in terms of historical preservation. Official visitors to the site are not discouraged from picking up the remaining fragments of trinitite, and the writer witnessed one person recover a fragment of partially fused concrete that may well have come from a concrete pier of the bomb tower. Remaining instrument and camera bunkers are in poor condition and will doubtless meet the same fate as the command bunkers unless a preservation policy is adopted soon. The Jumbo container has been badly damaged with torches in the attempt to cut it into manageable pieces for transportation to a nearby town (Las Cruces or Alamogordo) as a "souvenir." The condition of the McDonald Ranch is unknown.

It is strongly recommended: (1) that the Trinity Site (Ground Zero and all surrounding structures, remains, and sites, including the McDonald Ranch) be declared a Landmark eligible; and (2) that the Service, in cooperation with the AEC and the Department of Defense,

prepare a site study resulting in an historical base map and a preservation policy relating to each significant site, structure, or remain at the Trinity Site and vicinity.

Obviously, the Trinity Site cannot become a National Park now. But someday, 20, 30, 40, 50 years hence, this site will be free of present restrictions, and historically it will be even more important than it is now. If deterioration, destruction, and vandalism are allowed to proceed as in the past, this site--like few others, a part of the world's heritage--will disappear entirely.

References: The Atom (LASL, July 16, 1965); Richard Hewlett, The New World, 1939-46: A History of the United States Atomic Energy Commission (vol. 1, Pennsylvania State University Press, 1962); The First 20 Years at Los Alamos (LASL, 1963).

SITES ALSO CONSIDERED

1. Fort Whipple, Arizona

Location: Yavapai County, 1 mile east of Prescott on Alt. U.S. 89.

An interesting chapter in the history of Southwestern natural science was provided by the corps of distinguished Army surgeon-naturalists stationed at various military posts during the latter part of the 19th century. Most influential of these was Dr. Elliott Coues, one of the greatest ornithologists of all time and a prolific writer on the subject. His two-volume Key to North American Birds is a monument to his genius and literary skill. While Audubon popularized and dramatized ornithology, Coues unified and stabilized it as a science of the highest order. He was a founder of the American Ornithologists' Union.

Headquarters for Coues' extensive field work in Arizona and New Mexico was Fort Whipple near Prescott, Arizona, presently a veterans hospital with a number of buildings remaining from the late military period.

2. Camp Verde, Arizona

Location: Yavapai County, at town of Camp Verde, off State Route 79.

Dr. Edgar Alexander Mearns, also an Army surgeon-naturalist, was only slightly less influential than Coues on the course of Southwestern natural science. During the 1880s he was stationed at Camp Verde,

Arizona, and began the collection of plants and animals that, by the time of his death in 1916, made him the greatest single contributor of biological collections to the United States National Museum. In the period 1892-94, he explored the entire international boundary between El Paso and San Diego, collected 30,000 specimens, and became the leading authority on the flora and fauna of the boundary region. His collections of plants made in Grant County, New Mexico, were critical in the preparation of the first state flora. In 1908 he was selected by Theodore Roosevelt as naturalist on the Roosevelt Expedition to Africa. A tablet set in a ledge on Plummers Island in the Potomac River above Washington, a rallying place for naturalists, marks the spot where his ashes were scattered.

Camp Verde, a well preserved and administered historic site in Arizona, is well suited to commemorate Dr. Mearns' work.

3. Meteor Crater, Arizona

Location: Coconino County, 5 miles south of U.S. 66.

D. M. Barringer's studies of meteorites at Meteor Crater date from 1905. These studies were the prelude to quite significant work in the 1930s on the composition of meteors, affects of impact of meteorites, etc. Though Meteor Crater is more logically a candidate for Natural Landmark status, Barringer's work is significant in the history of science in its own right.

4. Fort Wingate, New Mexico

Location: McKinley County, 3 miles south of Interstate 40.

Perhaps the most famous independent plant collector of the Southwest was Edward Palmer, who did extensive field work in New Mexico, Arizona, and Utah in the 1870s. Unfortunately, his vast collections, stored in the U.S. National Herbarium, were little used, therefore his work did not achieve the significance of other less careful naturalists. Fort Wingate New Mexico, was one of Palmer's more important base camps.

5. Los Alamos Scientific Laboratory, New Mexico

Location: Los Alamos.

Los Alamos Scientific Laboratory, founded January 1, 1943, does not meet the criterion of age, but it is so significant in its contributions to the birth of the Nuclear Age, that 50 years of perspective seems hardly necessary.

The history already made at Los Alamos has been momentous for the entire world. The Laboratory was founded for the purpose of developing an instrument of war, the nuclear fission bomb. Successful in that task, LASL undertook a second assignment--creation of a "super" weapon deriving energy from the thermonuclear fusion of hydrogen. This mission, too, was successful. Since that time the Laboratory has continued to be the nation's foremost development center for nuclear weapons. More than 90% of the fission and fusion warheads now in American stockpiles are LASL devices.

The other half of LASL's history--the nonmilitary half--is equally impressive. Ever since 1943 the Laboratory has been making contributions

to fundamental scientific knowledge and to peaceful applications of atomic energy. The world's first enriched-uranium reactor was designed and built at Los Alamos, where it has been in operation since 1944. The world's first plutonium-fueled reactor went into operation at Los Alamos in 1946. This was also the world's first fast-neutron reactor. In more recent years the Laboratory has developed a reactor using uranium phosphate fuel and another using molten plutonium, both for the first time anywhere. Several rocket propulsion reactors have been built and ground tested, with flight tests scheduled in the next few years. The Laboratory continues to be a leader in many other peaceful fields, including chemistry and metallurgy, biology and medicine, thermionic electricity, plasma physics, instrument development and electronic computing.

This Office disagrees with the recommendation of Dr. Richard Hewlett of the AEC that Los Alamos not be accorded "exceptional value" classification. LASL's role as the focal point of nuclear weapon research and development (as contrasted to the development and production of nuclear materials at Oak Ridge and Richland), and the concentration here of an unparalleled pool of scientific talent (Oppenheimer, Fermi, Bethe) seems to us to warrant this divergence of opinion. It is requested that the Consulting Committee and the Advisory Board take into account this difference of opinion in judging the site.[1]

1. See attached copy of The Atom (LASL, July 16, 1965).

6. Fremont Campsite, Utah

Location: Utah County, near town of Spanish Fork.

The prerequisite of scientific work in the West was a firm geographic foundation. The last great mystery of American geography was finally and definitively solved by John C. Fremont during his second exploration of the West in 1844. He it was who destroyed one of the most persistent myths of American exploration by disproving the existence of the San Buenaventura River which was supposed to drain the vast interior between the Wasatch Range and the Sierra Nevadas. Having circled the area surrounding the Great Salt Lake, he concluded that it was a region of interior drainage with no outlet to the sea. On one of the most important maps in the history of American cartography,[1] he called it "The Great Basin"--a fundamental revelation in American geography and a scientific achievement of the first rank.

Fremont, according to his Report, formulated his Great Basin conclusion while encamped on the southwest shore of Lake Utah at the approximate site of the modern town of Spanish Fork. According to Dr. Everett Cooley, Director of the Utah Historical Society, no attempt has ever been made to locate the exact site, beyond this approximation. Fremont's Report provides no specific data or descriptions of terrain that could be employed for this purpose. Today the area of Fremont's camp is farm land with enclaves of urban and industrial development.

1. Map of an Exploring Expedition to the Rocky Mountains in the Year 1842 and to Oregon and North California in the Years 1843-44, drawn by Charles Preuss (Washington, 1845).

APPENDIX

Discussion of Lost or Unidentifiable Sites

Systematic scientific work by Anglos began in the Southwest with the Army exploring expeditions and surveys of the 19th century, most particularly during the period 1838 to 1863 under the direction of the Topographical Engineers.

The Maj. Stephen H. Long Expedition of 1819-20 is representative of the earlier Army explorations, including in its civilian contingent such emminent scientists as Thomas Say, zoologist, Augustus E. Jessup, geologist, and Edwin James, botanist. Despite the luster of these names, the scientists did not produce memorable results on the Long Expedition. More significant than their collections of new species of plants and animals, was Long's description of the High Plains as "The Great American Desert," a conception that has been bitterly fought ever since, but which, nevertheless, has been substantially vindicated by men like Powell and Webb, and has proved the determining factor of human ecology in the arid West.

No site in Southwest Region can be isolated to commemorate the Long Expedition.

* * * * * *

During the period of the Mexican War a number of Army expeditions explored the Southwest. Fremont crossed the Great Salt Desert of Utah. Lts. James W. Abert and William G. Peck explored the Canadian River

country and, later, New Mexico. Lt. William H. Emory mapped Texas and accompanied General Kearny's Army of the West from Fort Leavenworth to California via the Gila route across Arizona. Capt. George W. Hughes marched with General Wool's army across Texas into Mexico. In general, these expeditions subordinated science to military considerations. They did, however, make notable contributions to scientific geography, and Emory collected and described many new plant species, including the first scientific description of the giant cactus of Arizona.

Aside from the difficulty of locating significant sites to commemorate the Mexican War Reconnaissance, the nature of the scientific work was superficial, as might be expected during military campaigns in the midst of enemy territory.

* * * * * * * *

The Pacific Railroad Surveys of 1853-55, in addition to their great geographic contributions, dwarfed all previous scientific assaults on the Trans-Mississippi West. The 17 published volumes of the Pacific Railroad Reports, plus scores of learned papers stemming from data collected during the Surveys, comprised a huge compendium that defined the scientific outlines of the Far West. One hundred and six scientifically trained men accompanied the Topographical Engineers making the Surveys. Most of them were protégés of and had been appointed by America's top scientists--men like Baird of the Smithsonian, Hall, Torrey, Agassiz. The main function of these field men

was to collect and describe all phenomena of any scientific interest and bring the data back East to be classified by their mentors.

The Surveys were conducted with such speed that it was impossible to pursue specific scientific problems to conclusion. Thus, despite the masses of biological data collected and the excellent work in geology, particularly in describing the forces of erosion, the ultimate scientific results of the Surveys were disappointing in terms of theories or encompassing generalizations. Primarily, the work resulted in rather superficial geological description and classification of new biological species. This was natural, for classification and description were the prevailing scientific approaches of the time. Also, the very mass of new data and the great complexity of Western geology prevented research in depth. The Railroad Surveys produced a fast scientific reconnaissance and a broad view at the level of discovery. It would be the job of future generations to digest and put to use the immense amounts of data the Surveys had collected. Despite their limitations, the Railroad Surveys were immensely significant in opening up whole regions that had been virtually unknown to science.

Though the Railroad Surveys traversed large parts of Southwest Region and contributed valuable scientific data, especially the geological work of William P. Blake in Oklahoma's Antelope Hills, there seems to be no particular site that illustrates more than a fragment of this contribution.

* * * * * * * *

As stated in the Introduction, some notable applications of Eastern inventions occurred in Southwest Region. One of these applications has been documented and its site approximated by Walter Prescott Webb. The invention was the Colt six-shooter; the event was the Battle of the Pedernales, fought in June 1844 about 50 miles above Seguin, probably in Kendall County, Texas. In this battle the famous Indian fighter Capt. Jack Hays led a group of Colt-armed Texas Rangers against a band of mounted Comanches and defeated them. The Rangers' success, according to participants, was made possible only because of the six-shooters, which, for the first time, gave white men a chance in mounted combat against Indians using fast firing bows-and-arrows. The Battle of the Pedernales revolutionized Plains warfare, for it proved the utility of the six-shooter "as the only weapon which enabled the frontiersman to defeat the mounted Indian in his own peculiar mode of warfare."[1]

Unfortunately, the site of the Battle of the Pedernales is only approximate.

* * * * * * * *

According to A.R. Mortensen of the Utah State Historical Society, two potential "invention" sites exist in Utah: one associated with John M. Browning of Ogden, pioneer inventor of automatic weapons; and a second relating to the early electronic and radio developments of Philo Farnsworth. Neither the significance of these men's work nor potential sites associated with them have been evaluated at this writing.

1. Quoted from the 1850 testimonial of Maj. George T. Howard, Texas Army.

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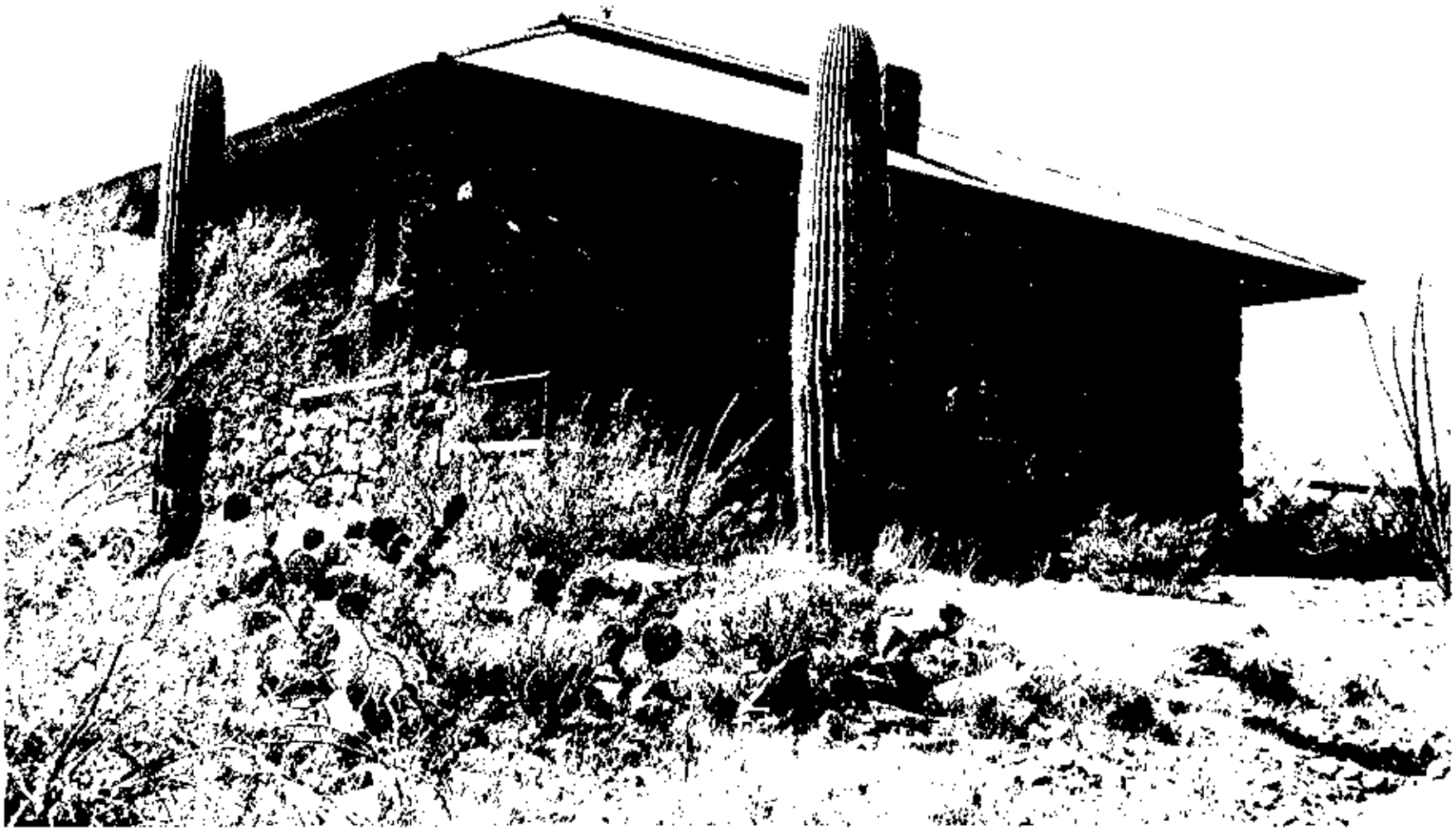
MERRIAM BASE CAMP: Little Spring Cove (spring pools in foliage).
NPS Photo, 9/64.

MERRIAM BASE CAMP: Little Spring Meadow, looking west from spring and campsite. NPS Photo, 9/64.

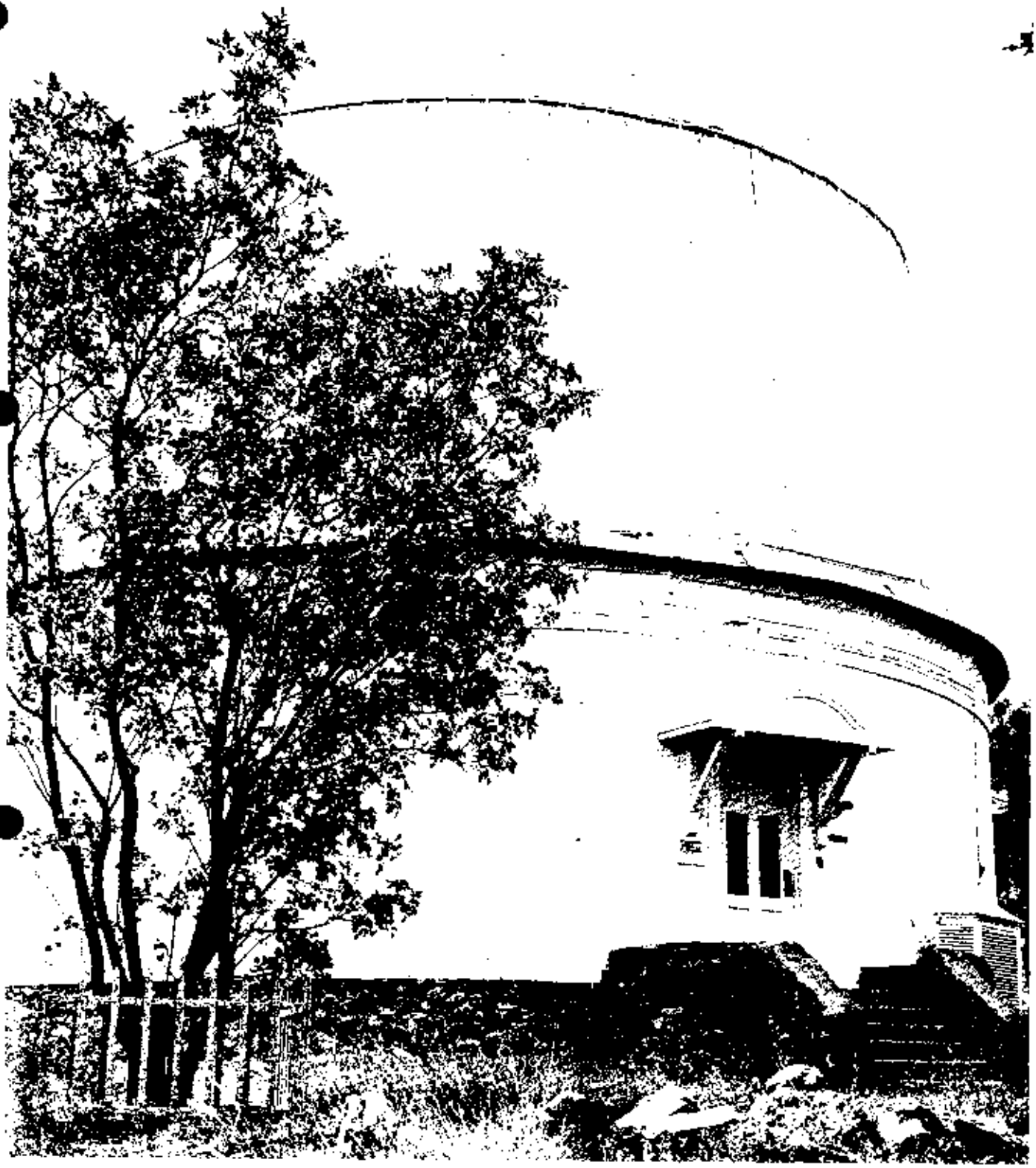
DESERT LABORATORY: Original wing of main laboratory, built in 1903.
NPS Photo, 9/64.



DESERT LABORATORY: Building No. 2 (extension of main laboratory), built in 1906.
NPS Photo, 9/61.

DESERT LABORATORY: Addition to main laboratory, including greenhouse, built in 1906. NPS Photo, 9/64.

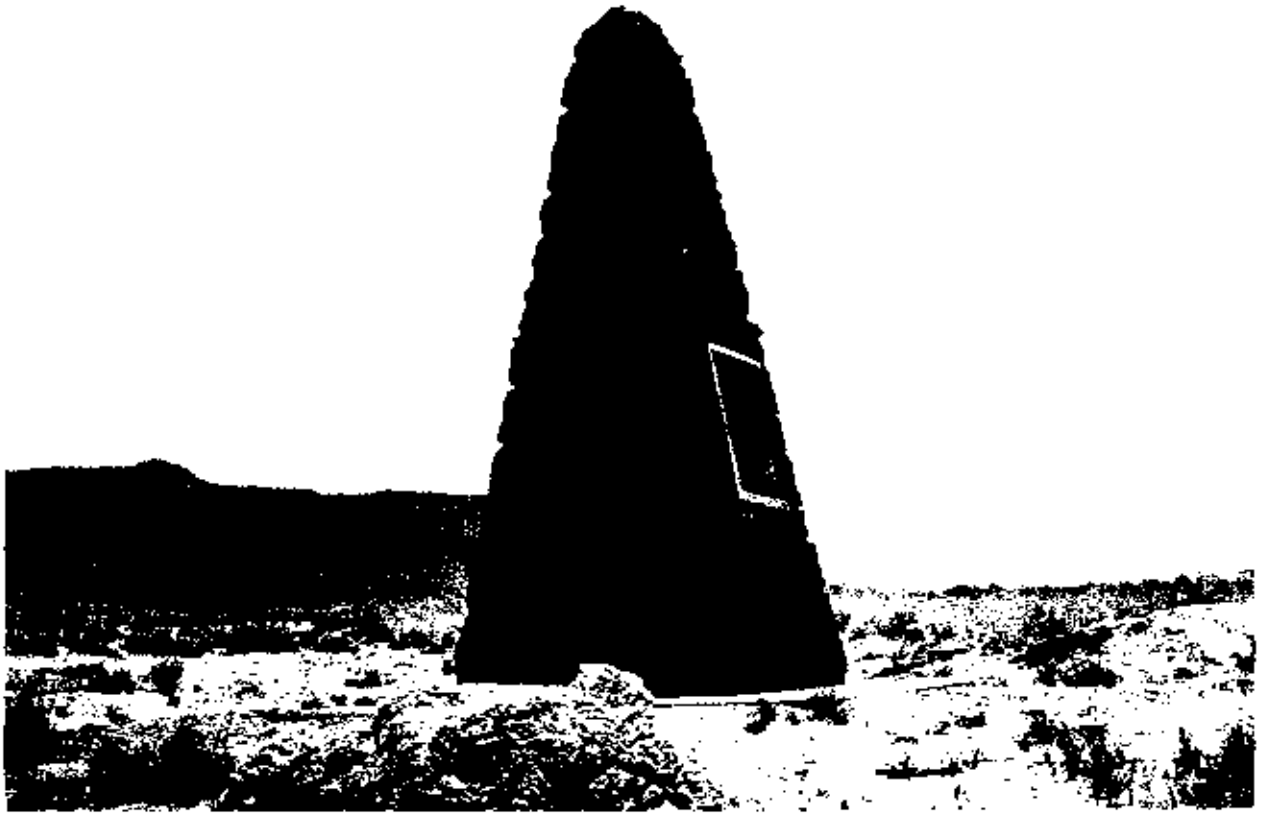
DESERT LABORATORY: Building No. 3 (originally a residence for scientists), built in 1906. NPS Photo, 9/64.



LOWELL OBSERVATORY: Original housing (1896) of 24-inch Lowell Refracting Telescope. This historic instrument still in use. NPS Photo, 9/64.

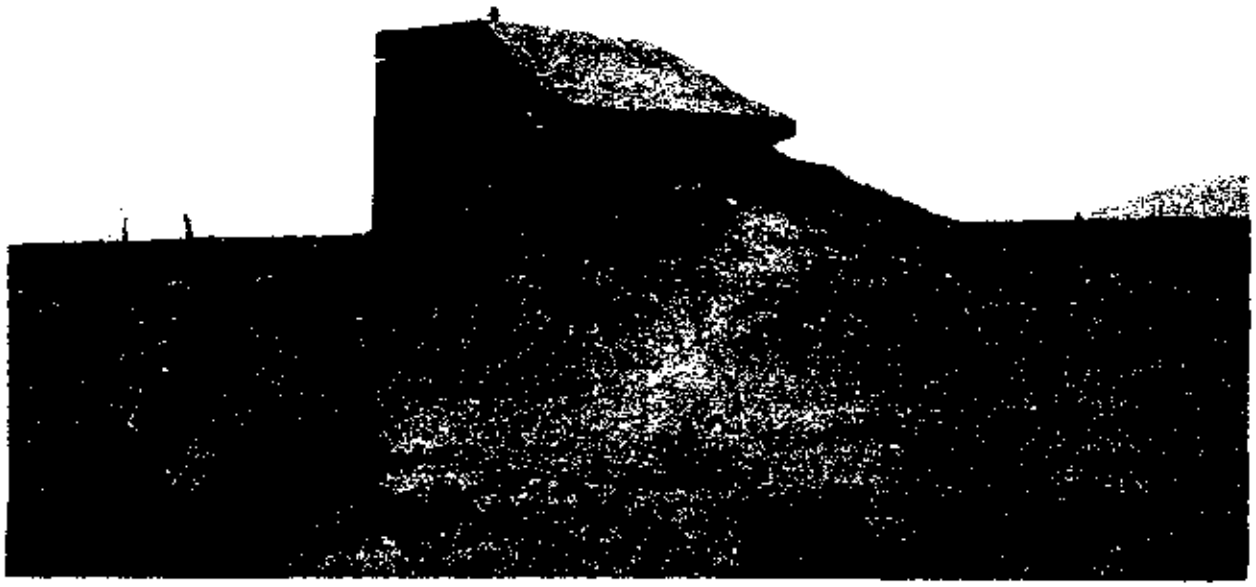
LOWELL OBSERVATORY: Original laboratory, library, and office (1894); now used as residence. NPS Photo, 9/64

LOWELL OBSERVATORY: Present administration and laboratory building (1914).
NPS Photo, 9/64.



Remains of concrete pier at northwest corner
of Ground Zero (immediate foreground).
NPS Photo, 7/65.

Closeup of Trinity Site Monument.
NPS Photo, 7/65.



Deteriorated camera bunker one mile north of Ground Zero; two others are in similar condition. NPS Photo, 7/65.

Remains of vandalized Jumbo container 800 feet west of Ground Zero. Twisted stumps of steel girders from Jumbo tower on skyline. NPS Photo, 7/65.

August '64

SOUTHWEST REGION

Preliminary Contribution and
Working List of Sites
for "Science and Invention"

INTRODUCTION

The Southwest was essentially a frontier environment throughout the period covered by this study. Thus one looks in vain for fundamental accomplishments in such pure sciences as physics and chemistry. Laboratory facilities of the type that would result in such accomplishments were nonexistent. The same sorts of environmental limitations apply to the field of invention, though there were some notable applications of inventions that had been developed in the East.

Very significant scientific work was done, however, in two fields: anthropology and the natural sciences--primarily biology and geology. Anthropology (including its subdisciplines--archeology, ethnology, linguistics, etc.), is not treated in this study, it being the opinion of this Region that this broad field should be incorporated into a special theme study dealing with the social sciences.

Thus we come to the crux of this discussion: the natural sciences. We may conceive of the Southwest as a great open book exhibiting some of nature's most stupendous wonders, some of its most fantastic geologic manifestations, some of its most variegated landscapes and life zones. As the Southwest was culturally a raw and extreme land, so was it raw and extreme in nature. From the time of the first Spaniard right up

to the present day the scientist has found nature exposed here, naked to the elements. In the deserts, in the mountains rising abruptly from the deserts, and in the canyons gashing the deserts, the scientist found incredible conjunctions in geology and biology. In a few hours he could hike from Sonoran desert to Alpine forest in Southwestern mountains, or descend through two billion years of earth history in Grand Canyon. Thus, in natural science, as in art and literature, the Southwest was the Nation's great outdoor laboratory and place of inspiration. Here came the savants of the East to gather objects and impressions which they took back East to their laboratories. For most of the period here considered, the basic approach to the Southwestern frontier in science, as in every other field, was extractive.

The history of science in the pre-1915 Southwest falls into two distinct, though overlapping, stages:

(1) The era of the field men who collected and classified;

(2) the era of the theorizers who systematized and synthesized.

In general, it may be said that finding sites to associate with the first era is difficult, for most of this work was accomplished by scientists accompanying government and military surveys and explorations. The groups conducting these expeditions were "passing through" and did not pause anywhere long enough to establish geographic points of special significance. There are a few sites, however, associated with the second era, as well as some that do not fit neatly into either category.

The material that follows, including site descriptions and evaluations of the work of particular outstanding scientists for whom it

would be desirable to find site associations, is based on preliminary documentary research and consultation with such noted authorities in the field of Southwestern natural science as Natt Dodge, former Regional Naturalist in this Office; Dr. William D. McDougal and Dr. Ardith Johnsen of the Museum of Northern Arizona; and Dr. C. P. Oliver, Chairman of the Zoology Department of the University of Texas. It should be emphasized that the findings are tentative and will have to be confirmed through further research, consultation, and field work--a task which will be completed by mid-September.

GENERAL DISCUSSION OF SITES AND SCIENTISTS

Spanish Period

Spanish expeditions into the Southwest were accompanied by scientists or naturalists who reported on the geography and the flora and fauna of the zones through which they passed. Thus Coronado's expedition reported the Grand Canyon and the buffalo. But these early observers made no notable contributions to theoretical science, nor did they often rise above the level of sheer wonderment at their discoveries.

With the coming of the Jesuits into southern Arizona a more systematic and profound scientific spirit was exhibited. Foremost among these missionaries was Father Eusebio Francisco Kino. His work as cartographer and geographer of Pimería Alta, as well as his descriptive writings, are still basic sources for naturalists, historians, and anthropologists concerned with this region. Being a man of many parts Kino does not fit neatly into any particular scientific niche, but he can well be termed the first scientist of the Southwest. As such he should be mentioned in this study, and either Tumacacori National Monument or San Xavier del Bac should be treated in the "Also Considered" category.

References: Herbert E. Bolton, Kino's Historical Memoir of Pimería Alta (Berkeley, 1948); _____, The Padre on Horseback (Chicago, 1963).

Perhaps the finest systematic scientific treatise rendered by a Jesuit missionary was Father Ignaz Pfefferkorn's Description of the Province of Sonora. The first volume of this work is a detailed

catalogue of the animal, plant, and mineral kingdoms in the region traversed by Pfefferkorn in his missionary travels. Though his longest assignments were at the missions of Atí and Cucurpe in what is now Sonora, Mexico, Pfefferkorn was also stationed at mission San Gabriel de Guebavi in Arizona at the junction of the Sonoita and Santa Cruz Rivers. Mission Tumacacori was one of Pfefferkorn's visitas at this time. His natural history of Sonora encompasses the entire geographic province up to the Gila River and is far and away the most significant work of its kind during the Spanish Period. Pfefferkorn's study of Sonoran natural phenomena is more than a historical curiosity. Today's naturalists find it an invaluable source for tracing the evolution of the Sonoran desert from the mid-18th century to the present.

The best site in the United States for commemorating Pfefferkorn's work is Tumacacori National Monument.

References: Elliott Coues, On the Trail of a Spanish Pioneer, Garces Diary, 1775-6 (New York, 1900); Ignaz Pfefferkorn, Sonora, A Description of the Province (Albuquerque, 1949).

Many other Spanish missionaries made scientific contributions, notable among them Garces and Escalante. But their work was not of the fundamental importance of that of Kino and Pfefferkorn.

Early Anglo Period

Systematic scientific work by Anglos began in the Southwest with the Army exploring expeditions and surveys of the 19th century, most particularly during the period 1838 to 1863 under the direction of the Topographical Engineers.

The Maj. Stephen H. Long Expedition of 1819-20 is representative of the earlier Army explorations, including in its civilian contingent such emminent scientists as Thomas Say, zoologist, Augustus E. Jessup, geologist, and Edwin James, botanist. Despite the luster of these names, the scientists did not produce memorable results on the Long Expedition. More significant than their collections of new species of plants and animals, was Long's description of the High Plains as "The Great American Desert," a conception that has been bitterly fought ever since, but which, nevertheless, has been substantially vindicated by men like Powell and Webb, and has proved the determining factor of human ecology in the arid West.

No site in Southwest Region can be isolated to commemorate the Long Expedition.

The prerequisite of scientific work in the West was a firm geographic foundation. The last great mystery of American geography was finally and definitively solved by John C. Fremont during his second exploration of the West in 1844. He it was who destroyed one of the most persistent myths of American exploration by disproving the existence of the San Buenaventura River which was supposed to drain the vast interior between the Wasatch Range and the Sierra Nevadas. Having circled the area surrounding the Great Salt Lake, he concluded that it was a region of interior drainage with no outlet to the sea. On one of the most important maps in the history of American cartography,[1] he called it "The Great

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1. Map of an Exploring Expedition to the Rocky Mountains in the Year 1842 and to Oregon and North California in the Years 1843-44, drawn by Charles Preuss (Washington, 1845).

Basin"--a fundamental revelation in American geography and a scientific achievement of the first rank.

Fremont, according to his Report, formulated his Great Basin conclusion while encamped at Utah Lake on May 23, 1844. Reportedly, this site can still be located today.

References: Gloria Griffen Cline, Exploring the Great Basin (Norman, 1963); William H. Goetzmann, Army Exploration in the American West, 1803-1863 (New Haven, 1959).

During the period of the Mexican War a number of Army expeditions explored the Southwest. Fremont crossed the Great Salt Desert of Utah. Lts. James W. Abert and William G. Peck explored the Canadian River country and, later, New Mexico. Lt. William H. Emory mapped Texas and accompanied General Kearny's Army of the West from Fort Leavenworth to California via the Gila route across Arizona. Capt. George W. Hughes marched with General Wool's army across Texas into Mexico. In general, these expeditions subordinated science to military considerations. They did, however, make notable contributions to scientific geography, and Emory collected and described many new plant species, including the first scientific description of the giant cactus of Arizona.

Aside from the difficulty of locating significant sites to commemorate the Mexican War Reconnaissance, the nature of the scientific work was superficial, as might be expected during military campaigns in the midst of enemy territory.

The Boundary Survey that fixed the line between Mexico and the United States in the early 1850s resulted in significant contributions in the fields of geography, geology, and biology. The most important document

relating to the subject is Emory's Report on the United States and Mexican Boundary Survey (Washington, 1859), which includes two volumes of scientific reports. In addition to the geographic and cartographic activities of the Topographical Engineers who conducted the survey, accompanying field scientists described the geology of the boundary region and collected many biologic specimens. These field reports and collections became the tools of Eastern scientists, who for the first time had adequate material to begin generalizing and theorizing about the Southwest. The region's geologic history was reconstructed. Doctor Parry and Arthur Schott advanced theories of mountain-making, continental uplift, igneous intrusion and inundation. Paleontologist James Hall correlated strata formations and began geologic mapping. Botanists John Torrey and George Englemann, basing their work on the Boundary Survey collections, produced monumental works on plant classification. Zoologists Baird and Girard of the Smithsonian Institution made similar contributions in their discipline. These various scientific labors, especially in the field of geology, resulted in the first groping attempts to assign principles of scientific causality to the natural history of the Trans-Mississippi West. Thus the scientific significance of the Boundary Survey can hardly be exaggerated.

The proposed Chamizal Memorial Park at El Paso, Texas, would be an ideal site at which to commemorate the scientific work of the Boundary Survey.

Reference: Goetzmann, Army Exploration.

The Pacific Railroad Surveys of 1853-55, in addition to their great geographic contributions, dwarfed all previous scientific assaults on the Trans-Mississippi West. The 17 published volumes of the Pacific Railroad Reports, plus scores of learned papers stemming from data collected during the Surveys, comprised a huge compendium that defined the scientific outlines of the Far West. One hundred and six scientifically trained men accompanied the Topographical Engineers making the Surveys. Most of them were protégés of and had been appointed by America's top scientists--men like Baird of the Smithsonian, Hall, Torrey, Agassiz. The main function of these field men was to collect and describe all phenomena of any scientific interest and bring the data back East to be classified by their mentors.

The Surveys were conducted with such speed that it was impossible to pursue specific scientific problems to conclusion. Thus, despite the masses of biological data collected and the excellent work in geology, particularly in describing the forces of erosion, the ultimate scientific results of the Surveys were disappointing in terms of theories or encompassing generalizations. Primarily, the work resulted in rather superficial geological description and classification of new biological species. This was natural, for classification and description were the prevailing scientific approaches of the time. Also, the very mass of new data and the great complexity of Western geology prevented research in depth. The Railroad Surveys produced a fast scientific reconnaissance and a broad view at the level of discovery. It would be the job of future generations to digest and put to use the immense amounts of data

the Surveys had collected. Despite their limitations, the Railroad Surveys were immensely significant in opening up whole regions that had been virtually unknown to science.

Though the Railroad Surveys traversed large parts of Southwest Region and contributed valuable scientific data, especially the geological work of William P. Blake, there seems to be no particular site that illustrates more than a fragment of this contribution.

References: Goetzmann, Army Exploration; George Leslie Albright, Official Explorations for Pacific Railroads, 1853-1855 (Berkeley, 1921)

An interesting chapter in the history of Southwestern natural science was provided by the corps of distinguished Army surgeon-naturalists stationed at various military posts during the latter part of the 19th century. Most influential of these was Dr. Elliott Coues, one of the greatest ornithologists of all time and a prolific writer on the subject. His two-volume Key to North American Birds is a monument to his genius and literary skill. While Audubon popularized and dramatized ornithology, Coues unified and stabilized it as a science of the highest order. He was a founder of the American Ornithologists' Union.

Headquarters for Coues' extensive field work in Arizona and New Mexico was Fort Whipple near Prescott, Arizona, presently a veterans hospital with a number of buildings remaining from the late military period. This might be an "Also Considered" site.

References: J. Stokley Ligon, New Mexico Birds (Albuquerque, 1961); Joseph Ewan, Rocky Mountain Naturalists (Denver, 1950); Florence Merriam Bailey, Birds of New Mexico (Albuquerque, 1928).

Dr. Edgar Alexander Mearns, also an Army surgeon-naturalist, was only slightly less influential than Coues on the course of Southwestern natural science. During the 1880s he was stationed at Camp Verde, Arizona, and began the collection of plants and animals that, by the time of his death in 1916, made him the greatest single contributor of biological collections to the United States National Museum. In the period 1892-94, he explored the entire international boundary between El Paso and San Diego, collecting 30,000 specimens and becoming the leading authority on the flora and fauna of the boundary region. His collections of plants made in Grant County, New Mexico, were critical in the preparation of the first state flora. In 1908 he was selected by Theodore Roosevelt as naturalist on the Roosevelt Expedition to Africa. A tablet set in a ledge on Plummers Island in the Potomac River above Washington, a rallying place for naturalists, marks the spot where his ashes were scattered.

Camp Verde, a well preserved and administered historic site in Arizona, is well suited to commemorate Dr. Mearns' work. It would be an "Also Considered" site.

References: Ligon, New Mexico Birds; Ewan, Rocky Mountain Naturalists.

Perhaps the most famous independent plant collector of the Southwest was Edward Palmer, who did extensive field work in New Mexico, Arizona, and Utah in the 1870s. Unfortunately, his vast collections, stored in the U.S. National Herbarium, were little used, therefore his work did not achieve the significance of other less careful naturalists.

Fort Wingate, New Mexico, was one of Palmer's more important base camps and can be listed in the "Also Noted" category.

References: Ewan, Rocky Mountain Naturalists; Rogers McVaugh, Edward Palmer, Plant Explorer of the American West (1956).

Late Anglo Period

The post-Civil War years inaugurated a new scientific era in the Southwest. The period of reconnaissance and discovery was largely replaced by one of research in depth and the beginnings of theoretical generalization--a trend that continued to gain momentum throughout the period under study.

Four geological and geographical surveys, later called the Great Surveys, undertook the massive task of finding out what lay west of the hundredth meridian. Parties led by Ferdinand Vandiveer Hayden, medical doctor turned geologist, Clarence King, aristocrat and intellectual, John Wesley Powell, conqueror of the Colorado River, and Lt. George M. Wheeler, determined military man and scientist, roamed over the wild country during the years 1867-79, observing, analyzing, theorizing, mapping, and, at the end of each season, returning to Washington to publish their results. The inquiries of the Great Surveys into geology, geography, and biology formed the basis for much of the knowledge of the physical West. Their scientific contributions were enormous, most of them published in some 120 major volumes listed in the Checklist of United States Public Documents, 1787-1901. In 1879 the Great Surveys were consolidated into the United States Geological Survey and the great work continued throughout the period of this study and down to the present day.

In terms of scientific achievement in Southwest Region, the giants of the Great Surveys and the subsequent U. S. Geological Survey were John Wesley Powell, Othniel C. Marsh, Grove Karl Gilbert, W. M. Davis, and C. E. Dutton.

Powell, explorer of the Colorado River and writer of a classic adventure story based on that exploration, is usually dismissed in just those words. But as Bernard DeVoto has pointed out in his introduction to Wallace Stegner's Beyond the Hundredth Meridian, Powell was a great scientist who used his knowledge to pierce through romantic misconceptions about the West and propose a realistic program for its development. Powell's Report on the Lands of the Arid Region of the United States is the first great scientific synthesis on the West. Here he used the methods and data of science to evolve an encompassing theory that would shape legal, political, and social institutions in a West dominated by the fact of aridity. Even if Powell had not been the prophet of the West, his work as geologist and ethnologist would have made him a great scientist. His founding of two of the most influential scientific government bureaus would have made him a great man.

Even though Powell's later activities were of much greater national importance, his river journey down the Colorado was, as Stegner puts it, symptom and symbol. Here he began the scientific approach to the West that would result in such momentous contributions. Both Grand Canyon National Park and Glen Canyon National Recreation Area are suited to commemoration of Powell's career.

References: Richard A. Bartlett Great Surveys of the American West (Norman, 1962); Wallace Stegner, Beyond the Hundredth Meridian (Boston, 1954).

Othniel C. Marsh, one of the greatest American paleontologists, President of the National Academy of Sciences, is chiefly remembered for his developmental history of the horse from eohippus to equus, the clinching documentation of the theory of evolution. His work in association with the Great Surveys and the U.S. Geological Survey was instrumental in fixing the geologic ages and tracing the story of plant and animal life in the West.

Marsh's work is commemorated by Marsh Peak in the Uinta Mountains of Utah where he did some of his most important field investigations, but no suitable historic site is known at the time of this writing.

References: Stegner, Beyond the Hundredth Meridian; Bartlett, Great Surveys; Charles Schuchert, O. C. Marsh, Pioneer in Paleontology (New Haven, 1940).

Grove Karl Gilbert's contributions to geology were of the same magnitude as Powell's. His brilliant theoretical mind and vivid imagination found its challenge in the questions raised by the geology of the Great Basin and the plateaus of Utah. Many of his theories have continued to be considered valid in the light of half a century of additional research.

Though he worked for 4 years with the Wheeler Survey, Gilbert's most important contributions date from his association with Powell, both in the Powell Survey and later with the U. S. Geological Survey. His "Report on the Geology of the Henry Mountains" (Powell Survey, 1877) developed the Laccolithic Theory, a major step forward in the understanding of volcanism. His "Lake Bonneville" (U.S. Geological Survey, 1890) was the definitive monograph on that subject. Gilbert, along with

W. M. Davis, was largely responsible for the creation of the subscience, physiography, which deals with the earth's surface and processes by which it is being changed.

Gilbert's base camp in the Henry Mountains of Utah would be an excellent site to commemorate his work. Field work is necessary to verify this site.

References: Carroll Lane Fenton and Mildred Adams Fenton, Giants of Geology (New York, 1952); Bartlett, Great Surveys; Stegner, Beyond the Hundredth Meridian.

Capt. Clarence E. Dutton was another Powell protégé who made his geological mark while associated with the Powell Survey and the U.S. Geological Survey. His Report on the Geology of the High Plateaus of Utah (Powell Survey, 1880) and his Tertiary History of the Grand Canyon District (U.S. Geological Survey, 1882) have ever since been scientific classics and established Dutton for all time as one of America's great geologists.

Grand Canyon National Park is the obvious commemorative site.

References: Bartlett, Great Surveys; Stegner, Beyond the Hundredth Meridian.

W. M. Davis ranks with Powell and Gilbert in the development of the science of physiography. Building upon the work of his predecessors, he added new principles to the science, outlined the theory of progressive stages in the development of land forms, and gave the science organization and definition. His Physical Geography, 1898, and Geographical Essays, 1909, are his most famous works. However, his extensive field work in the Grand Canyon and a number of basic monographs derived therefrom were instrumental in the development of his physiographic theories.

Grand Canyon National Park is again the suitable commemorative site.

References: Ralph Stockman Tarr, Physiography (New York, 1928); Edwin D. McKee, Ancient Landscapes of the Grand Canyon Region (Flagstaff, 1931).

As in geology, so in biology, the last years of the 19th century brought to the fore a distinguished group of synthesizers in the Southwest. Most important of these was the great zoologist Dr. C. Hart Merriam, who established the Life Zone concept in the 1890s in the San Francisco Mountains of Arizona. Merriam had accompanied the Hayden Survey in 1872, and was the founder and first chief of the U.S. Bureau of Biological Survey, predecessor of the present Fish and Wildlife Service.

Though hints of zonal distribution of plant and animal life had been dropped as early as the time of Humboldt, Merriam was the first to advance and define the Life Zone concept in scientific terms. In his treatise Results of the Biological Survey of the San Francisco Mountain Region and Desert of the Little Colorado in Arizona (1890), he graphically recorded his conclusions--that forms of life are peculiar to given altitudinal areas or zones, hence the designation of a region or zone by the presence of flora and fauna not found in others. Since temperatures on north slopes differ from those on south exposures, life zones do not run on arbitrary contours. Latitude is also important in determining climate. This combination of altitude, exposure, and latitude (climate) is basic in the ecology that governs the existing distribution of flora and fauna indigenous to the various regions.

Merriam's concept was fundamental in the development of the science of ecology--the most important modern generalization in the biological field. The high repute in which Merriam's work is still held is attested by the recent meeting at the Museum of Northern Arizona, attended by biologists from all over this Nation and Canada, commemorating his ecological studies in Northern Arizona.

Merriam's base camp at Little Springs in the San Francisco Mountains is still preserved and frequently visited. Pending field investigation, it would seem to be an "Exceptional Value" site.

References: Ewan, Rocky Mountain Naturalists; Ligon, New Mexico Birds; Dr. Ardith Johnsen, Museum of Northern Arizona.

Vernon Orlando Bailey, protégé and son-in-law of C. Hart Merriam, was Chief Naturalist of the Bureau of Biological Survey. In the field of mammology especially, he brought to fruition the Life Zone concept. His studies in New Mexico were very significant, resulting in a shelf of official Biological Survey reports. Florence Merriam Bailey, Vernon's wife, warrants the title of greatest American woman ornithologist. Though many of the publications of this husband-and-wife team date from the 1920s, the field work upon which these publications were based began in the 1890s. One of their favorite field locations was the Carlsbad-Guadalupe Mountains area of New Mexico and Texas. Vernon Bailey's Animal Life of Carlsbad Cavern is perhaps his finest ecological study.

Carlsbad Caverns National Park is the best site to commemorate the Baileys' work.

References: Ewan, Rocky Mountain Naturalists; Ligon, New Mexico Birds; Florence Merriam Bailey, Birds of New Mexico.

The Desert Laboratory of the Carnegie Institution of Washington opened in 1903 at Tucson, Arizona. For nearly half a century it was the center for the study of North American desert ecology. Notable among the distinguished scientists who made the Desert Laboratory a world-famous institution were Dr. D. T. MacDougal and Dr. Forrest L. Shreve. MacDougal's association with the Laboratory began in 1903; Shreve's in 1909. These men and their associates established the scientific foundations for the ecology of arid regions. Most important were their reports on the role of arid conditions in the evolution of flora and the migration of plants from humid zones.

The Desert Laboratory is now a unit of the University of Arizona and is located in the mountains west of Tucson. Depending upon the integrity of the site, it might be classified in either the "Exceptional Value" or the "Also Considered" categories.

References: Dr. Ardith Johnsen, Museum of Northern Arizona; Forrest Shreve and Ira L. Wiggins, Vegetation and Flora of the Sonoran Desert (Stanford, 1964).

Ernest Thompson Seton was a naturalist-popularizer who did for the Southwest what John Burroughs did for the Hudson River region. A prolific writer, he produced more than 40 volumes of nature studies, plus scores of scientific articles and treatises that are standard in every museum and zoo. To Seton belongs the credit for the modern method of field identification popularized by Roger Torey Peterson in his series of field guides. It was Seton who in his drawings first used that device of emphasizing the definitive characteristics of a species which can be observed from a distance. Seton illustrated all of his own books and

made hundreds of drawings for museums and other institutions. By many he is considered the best animal artist who ever lived. His magnum opus, Life Histories of North American Game Animals (1909), is a basic work in the field of scientific natural history and is used throughout the world as an authoritative reference on the life histories of North American mammals. Seton's work in the Southwest began in 1893.

Seton Village, just south of Santa Fe is a fitting site to commemorate Seton's life. Here are displayed thousands of his sketches and the 50-plus volumes of his scientific Journals upon which his writings were based. Because Seton Village dates from 1930 it should be treated in the "Also Considered" category.

Reference: Farida A. Wiley, ed., Ernest Thompson Seton's America (New York, 1954).

According to Professor C. P. Oliver of the University of Texas, the most important Texas scientist within the period of this study was Dr. William Morton Wheeler. As Professor of Zoology at the University of Texas, Dr. Wheeler performed fundamental research in entomology, particularly in his studies of ants. He was later associated with Eastern universities and became a member of the National Academy. As related by Dr. Oliver, Wheeler's published studies are basic works in the science of entomology.

Other important work was done in Texas in the fields of geology and biology, but, with the exception of Wheeler, particular scientists have not been evaluated at this writing. One site, however, can be listed: Big Bend National Park. According to Dr. Oliver, the Big Bend country was the great outdoor laboratory of Texas scientists, in much the same

way that the Grand Canyon served scientists farther west. At Big Bend are found the same sorts of startling geologic and biologic conjunctions. Since the turn of the century, this region has attracted many scientific expeditions which have attempted to unravel its complex geology and varied ecological patterns.

References: Dr. C. P. Oliver, University of Texas; "Big Bend National Park" (NPS informational booklet, 1963).

Lowell Observatory near Flagstaff, Arizona, was founded in 1894 by Dr. Percival Lowell. Within the period of this study, this observatory was the one significant center of "pure" science in Southwest Region. The observatory is noted for intensive studies of Mars (in connection with which Dr. Lowell advanced the theory that the plant was inhabited by intelligent beings), the discovery of Pluto, and Dr. Andrew Elliott Douglass' researches into zodiacal light and sunspot phenomena. In connection with this latter work, Dr. Douglass discovered dendrochronology, most often associated with archeology, but probably more fundamentally important in climatology.

The Lowell Observatory is an obvious candidate for "Exceptional Value" classification.

References: Dr. Ardith Johnson, Museum of Northern Arizona; Jack L. Cross, et al, Arizona, Its People and Resources (Tucson, 1960); Douglass obituary.

D. M. Barringer's studies of meteorites at Meteor Crater, Arizona, date from 1905. These studies were the prelude to quite significant work in the 1930s on the composition of meteors, affects of impact of meteorites, etc.

Though Meteor Crater is more logically a candidate for Scientific Landmark status, it should be listed in the "Also Noted" category in this study.

References: Dr. Ardith Johnsen, Museum of Northern Arizona; D. M. Barringer, Coon Mountain and Its Crater (1905).

Los Alamos Scientific Laboratory, founded January 1, 1943, does not meet the criterion of age, but it is so immensely significant as the birthplace of the Nuclear Era, that 50 years of perspective seems hardly necessary.

The history already made at Los Alamos has been momentous for the entire world. The Laboratory was founded for the purpose of developing an instrument of war, the nuclear fission bomb. Successful in that task, LASL undertook a second assignment--creation of a "super" weapon deriving energy from the thermonuclear fusion of hydrogen. This mission, too, was successful. Since that time the Laboratory has continued to be the nation's foremost development center for nuclear weapons. More than 90% of the fission and fusion warheads now in American stockpiles are LASL devices.

The other half of LASL's history--the nonmilitary half--is equally impressive. Ever since 1943 the Laboratory has been making contributions to fundamental scientific knowledge and to peaceful applications of atomic energy. The world's first enriched-uranium reactor was designed and built at Los Alamos, where it has been in operation since 1944. The world's first plutonium-fueled reactor went into operation at Los Alamos in 1946. This was also the world's first fast-neutron reactor. In more recent years the Laboratory has developed a reactor using uranium phosphate

fuel and another using molten plutonium, both for the first time anywhere. Several rocket propulsion reactors have been built and ground tested, with flight tests scheduled in the next few years. The Laboratory continues to be a leader in many other peaceful fields, including chemistry and metallurgy, biology and medicine, thermionic electricity, plasma physics, instrument development and electronic computing.

It is the recommendation of this Office that LASL be accorded "Exceptional Value" classification. We would also recommend for classification the Trinity Site in southern New Mexico where the first atomic bomb test occurred on July 16, 1945, except that this site is completely closed to the public, locked tight in an Army testing range. Eventually, as was proposed shortly after World War II, this site will probably become a unit of the National Park System.

References: LASL, The First 20 Years at Los Alamos (1963); _____, Facts About Los Alamos Scientific Laboratory of the University of California (1963).

Invention

As stated above, some notable applications of Eastern inventions occurred in Southwest Region. One of these applications has been documented and its site approximated by Walter Prescott Webb. The invention was the Colt six-shooter; the event was the Battle of the Pedernales, fought in June 1844 about 50 miles above Seguin, probably in Kendall County, Texas. In this battle the famous Indian fighter Capt. Jack Hays led a group of Colt-armed Texas Rangers against a band of mounted Comanches and defeated them. The Rangers' success, according to participants, was made possible only because of the six-shooters, which, for

the first time, gave white men a chance in mounted combat against Indians using fast firing bows-and-arrows. The Battle of the Pedernales revolutionized Plains warfare, for it proved the utility of the six-shooter "as the only weapon which enabled the frontiersman to defeat the mounted Indian in his own peculiar mode of warfare."[1]

Unfortunately, the site of the Battle of the Pedernales is only approximate. It should, however, be listed in the "Also Noted" category. Reference: Walter Prescott Webb, The Great Plains (Boston, 1931).

According to A. R. Mortensen of the Utah State Historical Society, two potential "invention" sites exist in Utah: one associated with John M. Browning of Ogden, pioneer inventor of automatic weapons; and a second relating to the early electronic and radio developments of Philo Farnsworth. Neither the significance of these men's work nor potential sites associated with them have been evaluated at this writing.

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1. Quoted from the 1850 testimonial of Maj. George T. Howard, Texas Army.

WORKING LIST OF SITES

Units of the National Park System

Grand Canyon National Park, Arizona (Powell, Dutton, Davis)

Glen Canyon National Recreation Area, Arizona-Utah (Powell)

Tumacacori National Monument, Arizona (Kino, Pfefferkorn)

Carlsbad Caverns National Park, New Mexico (Baileys)

Big Bend National Park, Texas

Sites of Exceptional Value

*C. Hart Merriam Base Camp, San Francisco Mountains, Arizona

*Desert Laboratory, Tucson, Arizona (Shreve, MacDougal)

-Lowell Observatory, Flagstaff, Arizona (Lowell, Douglass)

Los Alamos Scientific Laboratory, New Mexico

*Fremont Campsite, Utah Lake, Utah

*Gilbert Base Camp, Henry Mountains, Utah

Sites Also Considered

San Xavier del Bac, Arizona (Kino)

Fort Whipple, Arizona (Coues)

Camp Verde, Arizona (Mearns)

Seton Village, New Mexico

Trinity Site, New Mexico (Atomic Bomb Test)

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*Tentative pending site verification

Also Noted Sites

Meteor Crater, Arizona (Barringer)

Fort Wingate, New Mexico (Palmer)

Antelope Hills, Oklahoma (Blake-Pacific Railroad Surveys)

Pedernales Battlesite, Texas (Colt six-shooter)

Proposed Site

Chamizal Memorial Park, El Paso, Texas (Mexican Boundary Survey)

1964

SCIENCE AND INVENTION

Results of Field Work
on Sites Recommended for
Exceptional Value in Southwest Region

Southwest Region
National Park Service
Santa Fe, New Mexico

Introduction

In the theme study, "Science and Invention," this Region tentatively recommended six sites for "exceptional value" classification, pending field verification. The field work on these sites has been completed and the summary results are given below:

Recommended for Exceptional Value

C. Hart Merriam Base Camp, Arizona

Desert Laboratory, Arizona

Lowell Observatory, Arizona

Recommended for Sites Also Considered

Gilbert Base Camp, Utah

Recommended for Also Noted Sites

Fremont Campsite, Utah

Recommended for Special Study

Los Alamos Scientific Laboratory, New Mexico

Discussion of Individual Sites

First, to dispose of the sites that are no longer recommended for "exceptional value" classification:

Grove Karl Gilbert Base Camp in the Henry Mountains, Utah

As a result of additional research in Salt Lake City, it is apparent that Gilbert's work in the Henry Mountains of Utah in 1875-76 and his later tracing of the geologic history of ancient Lake Bonneville establish him as one of America's great geologists.

Dr. Charles B. Hunt, modern authority on the Henry Mountains, has this to say concerning Gilbert's contributions:

> "The Henry Mountains region in southeastern Utah is one of the classic areas in geology because of the study made there by Grove Karl Gilbert in 1875 and 1876. His report on the geology of the mountains was the first to recognize that intrusive bodies [laccoliths] may deform their host rocks and the first to show clearly the significance of the evenly eroded plains, now known as pediments, at the foot of desert mountains."
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> . . . . . .
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> "The brilliance of Gilbert's report has been acknowledged by widespread interest manifested in it by geologists throughout the world, assuredly the highest form of tribute that science can pay for an outstanding contribution. For more than 60 years the Henry Mountains have been referred to in the geological literature of every language and are one of the localities most widely known to the science. No geologist needs to be introduced to them."

Locating a site to commemorate Gilbert's scientific research in the Henry Mountains has, unfortunately, proved difficult. His field notes indicate that he had a number of base camps, none of which is clearly superior to the others as a commemorative site. Cache Camp, or Camp No. 1, located by Dugout Creek where it leaves the western slopes of Mount Ellen, was a main supply point. But the site is impossible of precise identification.

Recognition of Gilbert's geological contributions is possible by a number of other means. The McMillen Springs Campground of the Bureau of Land Management is near the Dugout Creek site, and an interpretive plaque or exhibit could be installed there describing Gilbert's work and the importance of the Henry Mountains as the "type site" for the laccolithic phenomenon. The Henry Mountains overshadow Capitol Reef National Monument, and this was the jumping off point for the important

1876 expedition. Gilbert and the Henry Mountains could appropriately be worked into the interpretive program at the monument. Any number of sites illustrate Gilbert's work on Lake Bonneville: e.g., ancient shorelines on the north end of the Oquirrh Range, terraces on Antelope Island, Preuss Valley, Provo shoreline, deltas of Logan River, and Black Rock and vicinity. The Great Salt Lake Authority is presently planning a state park encompassing Antelope and Fremont Islands, and, according to State Park Commission officials, would tell the Lake Bonneville story in the interpretive program. Finally, in view of the Henry Mountains' importance as a geological "type site," the entire range (controlled by the Bureau of Land Management) might be designated as a Registered National Scientific Landmark.

In view of the difficulty of pinpointing the exact location of Gilbert's Cache Camp, it is recommended for the "Sites Also Considered" category.

References: G. K. Gilbert, Report on the Geology of the Henry Mountains, Department of the Interior, U.S. Geographical and Geological Survey of the Rocky Mountain Region, J. W. Powell in Charge (Second Ed., Washington, GPO, 1880); Charles B. Hunt, Geology and Geography of the Henry Mountains Region, Utah, Geological Survey Professional Paper 228 (Washington, GPO, 1953); G. K. Gilbert, Lake Bonneville, U.S.G.S. Monograph #1 (Washington, GPO, 1890).

Fremont Campsite, Utah Lake, Utah

John Charles Fremont's "Great Basin" concept remains one of the stellar scientific illuminations of American history. His Report indicates that his conclusion concerning the vast area of interior drainage between the Wasatch Range and the Sierra Nevadas came on May 25, 1844, on

the southwest shore of Lake Utah at the approximate site of the modern town of Spanish Fork. According to Dr. Everett Cooley, Director of the Utah Historical Society, no attempt has ever been made to locate the exact site, beyond this approximation. Fremont's Report provides no specific data or descriptions of terrain that could be employed for this purpose.

Today the area of Fremont's camp is farm land with enclaves of urban and industrial development. It is therefore recommended for the "Also Noted Sites" category.

References: Brevet Captain J. C. Fremont, Report of the Exploring Expedition to the Rocky Mountains . . . (Washington, 1845).

Los Alamos Scientific Laboratory, New Mexico

We continue to believe that this site is of such great significance that it transcends the 50-year limitation. In line with the deliberations of the Consulting Committee, however, we now recommend that LASL be included in a special comparative study of atomic energy sites.

* * * * *

Field work has verified the three sites discussed below, and we hereby reaffirm our recommendation that they be considered for "exceptional value" classification:

C. Hart Merriam Base Camp, San Francisco Mountains, Arizona

Significance: Additional research at the Museum of Northern Arizona and discussions with Drs. Ardith Johnsen and W. P. McDougall of the museum staff confirm C. Hart Merriam's national significance as a biologist.

He was America's first bio-ecologist. His study of the San Francisco Mountains biota was the first correlation of both plants and animals. His "laws of temperature" delimiting life zones and life distribution were fundamental to the Life Zone Concept.

It is true that Merriam over-generalized and made mistakes. But his work was germinal to the development of the modern science of ecology. He was a catalyst who opened the gates on what has proved to be the most fruitful line of approach in modern biological science. Not only were his correct deductions and generalizations useful, but in the very process of disproving his errors, other scientists were stimulated to make fundamentally important contributions. In a sense, Merriam was to American biology what Frederick Jackson Turner was to American history: An overly complacent proponent of a theory that vitalized an entire science. All ecologists and zoologists know and refer to Merriam's work, and his report on the San Francisco Mountains continues to be cited as the pioneer model for bio-ecological studies.

The noted biologist Rexford F. Daubenmire has summed up Merriam's contributions as follows:

> "In all fairness, however, we must recognize the value of Merriam's life-zone work as a contribution to biology. His was the first major attempt to use climatic data in interpreting the distribution of North American biota, and to base distributional provinces on both plants and animals. It is also to Merriam's credit that he deplored the use of daily, monthly, or annual climatic data and recommended that the intervals used have less arbitrary bases..... Although his explanations may be .../often/ fallacious, they have greatly stimulated inquiry into the causes of plant and animal distribution."

> "The descriptive parts of his field surveys were very accurate and for a long time have been standard references on vegetation zones of western United States of America. Indeed many western biologists...still use Merriam's terminology for the various zones....."

Another commentator on the life sciences, S. Charles Kendeigh, after discounting Merriam's errors, stresses the fundamental provocative nature of his work and the continuing basic use of the life zone tool locally and regionally, wherever ecological studies are in progress.

Present Status: In the itinerary section of his report on the San Francisco Mountains, Merriam states:

> "After spending three days in outfitting /at Flagstaff/, we proceeded to Little Spring, at the north base of San Francisco Mountain, and pitched our tents in a grove of aspens and pines, on a knoll just northwest of the spring, at an altitude of 2,500 meters (8,250 feet). This was our base camp for two months /August and September, 1889/, and from it numerous side-trips were made into the surrounding country."

Today Little Spring is in a private enclave within the boundary of Coconino National Forest. The land is part of the C. O. Bar Livestock Company, owned by Mr. John Babbitt of Flagstaff.

As shown by the photos in the album, the site retains complete integrity. The spring cove is on a slope that opens upon a beautiful meadow. Wildlife and handsome trees, including very large aspens, give the scene a pristine quality that recalls its charm for a biological investigator. Little Spring is easily reached by a good Forest Service road.

References: C. Hart Merriam, Results of a Biological Survey of the San Francisco Mountain Region . . . U.S.D.A., Division of Ornithology and Mammalogy. North American Fauna Series #3 (Washington, 1890); Rexford F. Daubenmire, "Merriam's Life Zones of North America," Quarterly Review of Biology, XIII (Sept. 1938); S. Charles Kendeigh, "History and Evaluation of Various Concepts of Plant and Animal Communities in North America," Ecology, XXXV (April 1954).

Lowell Observatory, Flagstaff, Arizona

Discussions with Chief Astronomer Henry Giclas of Lowell Observatory confirmed the significance of Dr. Percival Lowell's visual observations of Mars, the pioneering approach to planetary astronomy; the discovery of Pluto; and Dr. A. E. Douglass' researches into zodiacal light and sunspot phenomena, and his discovery of dendrochronology.

Most important, however, is the fact that beginning in 1912 the Lowell Observatory discovered the first observational evidence of the expanding universe. This was a cosmological discovery of the first magnitude, ranking in the history of astronomy with the Copernican revolution. On the basis of this discovery alone, the Lowell Observatory must be considered one of the world's most important astronomical centers.

Present Status: Lowell Observatory stands on Mars Hill overlooking Flagstaff. It continues, in the tradition established by Dr. Lowell, in pursuing a broad program of astronomical research. Lowell established the observatory primarily for the purpose of studying the solar system and its evolution. The Planetary Library and Research Center of the observatory, and its status as the world center for planetary photography, are symbolic of the continuity of Lowell's original purpose.

The photo album shows the prime historical structures at the site, most important of which is the original 1896 housing for the historic 24-inch Lowell Refracting Telescope. This instrument, installed in 1896, has been in continuous operation since that time.

In every sense, the 700-acre site exhibits high integrity. The Lowell Observatory is a privately endowed scientific institution.

References: Interview with Chief Astronomer Henry Giclas; "The Lowell Observatory," 6-page folder issued at the observatory.

Desert Laboratory of the Carnegie Institution, Tucson, Arizona

The role of the Desert Laboratory as the pioneer world center for the study of arid-region ecology was established by additional research at the site, now the Geochronology Laboratory of the University of Arizona. These early studies covered not only the Southwest and northern Mexico, but expeditions sponsored by the Desert Laboratory conducted field experiments and observations in Australia, Asia Minor, Egypt, Sudan, Libyan Desert, Algeria, and South Africa. These various research projects of the Desert Laboratory concentrated on desert vegetation, with special attention to the morphology and physiology

of the spinose and succulent types which inhabit arid regions, their adjustments to arid conditions, distributional movements, and the phytogeography of deserts in general. Scores of major publications by the Carnegie Institution and hundreds of articles contributed to transactions of societies and to periodicals resulted from the researches at the Desert Laboratory. These contributions were instrumental in establishing the scientific bases for desert ecology, not only in the United States but throughout the world.

Present Status: The site encompasses some 800 acres on Tumamoc Hill, or "Science Hill," just west of Tucson. Three major buildings dating from the historic period are shown in the photo album. These buildings and a number of more recent structures are used as laboratories in the geochronology program of the University of Arizona. The purpose of the current program is to advance knowledge of geologic time, of past climates, and of evolution of terrestrial biotas. Thus there is a direct line of continuity in the scientific work at the site.

The Desert Laboratory was founded in 1903. The area was transferred to the U.S. Forest Service in 1940 as an experimental station, and in 1958 it became a unit of the University of Arizona. The grounds surrounding the laboratory are fenced to protect the many type specimens identified by the early botanists of the Carnegie Institution.

References: Annual Reports of the Carnegie Institution, 1903 et. seq.; Historical Files of the Desert Laboratory (in library of the University of Arizona).