

OMB Control #: (1024-xxxx)

Exp. Date: (To be Requested)

**APPLICATION FOR INCLUSION OF A PROPERTY
IN THE U.S. WORLD HERITAGE TENTATIVE LIST**

PAPERWORK REDUCTION ACT STATEMENT:

16 U.S.C. 470 a-1 authorizes collections of this information. This information will be used to help the Assistant Secretary for Fish and Wildlife and Parks prepare a “Tentative List” of candidate sites for possible nomination to the UNESCO World Heritage List. Response to this request is voluntary. No action may be taken against you for refusing to supply the information requested. A Federal agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

ESTIMATED BURDEN STATEMENT:

Public reporting burden for this collection of information is estimated to average 64 hours per response (ranging from 40 to 120 hours, depending on the complexity of the site), including the time for reviewing instructions, gathering and maintaining data, and completing and reviewing the form. Direct comments regarding this burden estimate or any other aspect of this form to the Office of International Affairs, National Park Service, 1849 C Street NW, Washington, D.C. 20240.

White Sands National Monument

Prerequisites for U.S. World Heritage Nominations

An application for a property that does not meet all of the prerequisites A through G, or for which answers are uncertain, should not be completed or submitted. Such a property cannot be legally considered. If you are in doubt about the answer to all these questions being anything other than “yes,” please contact the World Heritage Advisor at the address and phone number provided for further guidance.

Prerequisite 1 - Legal Requirements:

A. National Significance:

Has the property been formally determined to be nationally significant for its cultural values, natural values, or both (in other words, has it been formally designated as a National Historic Landmark, a National Natural Landmark, or as a Federal reserve of national importance, such as a National Park, National Monument, or National Wildlife Refuge)? If not, are there on-going processes to achieve any of the above designations and what is their status? (*Listing in the National Register of Historic Places is not equivalent to National Historic Landmark status.*)

YES: X NO:

Comment: White Sands is a National Monument. Herbert Hoover established the monument in 1933 to preserve the white sands and additional features of scenic, scientific and educational interest.

B. Owner Concurrence:

Are all the property owners aware of this proposal for the inclusion of the property in the U.S. Tentative List and do all of the property owners agree that it should be considered? If any agreement is uncertain or tentative, or if the ownership situation is disputed, otherwise complicated, or unclear, please explain the issues briefly.

YES: X NO:

Comment: The U.S. Army has a small in holding but is excluded from the nomination. The U.S. Army has provided a letter of support.

F. Serial (multi-component) Properties:

Are you proposing this property as an extension of or a new component to an existing World Heritage Site?

YES: _____ NO X

Name of Existing Site: _____

Prerequisite 3 - Other Requirements:

G. Support of Stakeholders

In addition to owners, please list other stakeholders and interested parties who support the property’s proposed inclusion in the Tentative List. Also note any known to be opposed.

Explanation: The purpose of the Tentative List is to propose candidate properties that are likely to be successfully nominated during the next decade. It is clear that a consensus among stakeholders will be helpful in nominating a site and later in securing its proper protection. Thus, only properties that enjoy strong, preferably unanimous, support from stakeholders will be recommended for inclusion in the U.S. Tentative List.

In addition to owners, stakeholders primarily include:

- Governors, Members of Congress and State legislators who represent the area where the property is located,*
- the highest local elected official, or official body, unless there is none,*
- Native Americans, American Indian tribes, or other groups and individuals who possess legally recognized claims or privileges in the area or at the site being proposed (e.g., life tenancy or hunting and fishing rights),*
- organizations established to advocate for protection and appropriate use of the property proposed for nomination.*

If definitive information is not available at the time you filled out this Questionnaire, please so indicate.

Supporters:

- Jeff Bingaman, United States Senator
- Pete Domenici, United States Senator
- Stevan Pearce, United States Representative
- Gloria Vaughn, State Representative, New Mexico
- Otero County, New Mexico
- Don Carroll, Mayor, City of Alamogordo, New Mexico
- Bill Mattiace, Mayor, City of Las Cruces, New Mexico

Opponents: _____

Comment: Native American Tribes affiliated with the monument were consulted and no comments were received. _____

Information Requested about Applicant Properties

(The numbers of the sections and subsections below are in the same order as and correspond to sections of the World Heritage Committee's official Format used for the nomination of World Heritage Sites. This is to allow easy reference to and comparison of the material.)

1. IDENTIFICATION OF THE PROPERTY OR PROPERTIES

1.a. Country:

If it is intended that the suggested nomination will include any properties in countries other than the United States, please note the countries here.

Explanation: Please note that the United States can nominate only property under U.S. jurisdiction. You are not expected to contact other governments and owners abroad, although you may do so if you wish. Each national government must nominate its own sites, although the United States will consider forwarding your suggestion to another government for that government to consider as a joint nomination with the United States.

Names of countries: United States _____

1.b. State, Province or Region:

In what State(s) and/or Territories is the property located? Also note the locality and give a street address if one is available.

Dona Ana and Otero Counties, New Mexico

19955 Highway 70 West, Alamogordo, NM 88310

or

PO Box 1086 Holloman AFB, NM 88330

1.c. Names of Property:

What is the preferred or proposed name of the property or properties proposed for nomination? If the site has multiple names, explain why you chose the primary choice or choices. (The name should not exceed 200 characters, including spaces and punctuation.)

Popular and Historic names

What are any popular or historic names by which the property is also known?

The area may be referred to simply as White Sands

Naming of serial (multiple component) properties and transboundary sites.

Try to choose brief descriptive names. In the case of serial nominations, give an overall name to the group (e.g., *Baroque Churches of the Philippines*). (Give the names of the individual components in a table that you insert under *If*.)

Group or Transboundary Name: _____

Other names or site numbers

Explanation: If a site has multiple names, explain why you chose the primary choice or choices. If the site has no common name or is known only by a number or set of numbers, please explain.

The name, White Sands National Monument, is preferred to avoid confusion with White Sands Missile Range.

1.d.-e. Location, boundaries, and key features of the nominated property

Include with this **Application** sketch maps or other small maps, preferably letter-size, that show:

- the location of the property
- the boundaries of any zones of special legal protection
- the position of major natural features and/or individual buildings and structures
- any open spaces (squares, plazas) and other major spatial relationships (the space between buildings may at times be more important than the buildings)

Please provide here a list of the maps that you have included.

Location within the United States of America

Location of the Property in New Mexico

Major Natural Features

1.f. Area of nominated property (ha.)

Explanation: State the approximate area proposed in hectares (1 hectare=2.471 acres). Give corresponding acre equivalents in parentheses. Insert just below this question a table for serial nominations that shows the names and addresses of the component parts, regions (if different for different components), and areas.

The monument has 58167 hectares (143,733 acres).

2. DESCRIPTION AND HISTORY OF THE PROPERTY

2.a. Description of the Property

Natural property

Briefly describe the property and list its major components. A summary in a few paragraphs or pages is all that is required.

Explanation: This section can describe the property's important physical features and scientific values, including geography, geology, topography, habitats, species and population sizes (including an indication of any that are threatened), and other significant ecological features and processes.

The White Sands National Monument is located at the northern end of the Chihuahuan Desert in the Tularosa Basin, west of Alamogordo, New Mexico. Here, great wave-like dunes of gypsum sand have engulfed 275 square miles of desert and have created the world's largest gypsum dune field. The brilliant white dunes are ever changing: growing, cresting, then slumping, but always advancing. Slowly but relentlessly the sand, driven by strong southwest winds, covers everything in its path. There are several major geologic and biological components to the monument including dunes, playa lakes and white animal species. The monument preserves a major portion of this gypsum dune field, along with the plants and animals that have successfully adapted to this constantly changing environment.

White Sands National Monument preserves a portion of the Chihuahuan Desert, which is the most biologically diverse desert in the Western Hemisphere and one of the most diverse arid regions in the world. The eastern boundary is one of the oldest and richest centers of plant evolution on the North American continent. The Chihuahuan Desert is a focal point for cactus diversity, many cactus species can be found nowhere else on Earth, with more than 400 species. In addition, the region supports a great variety of bats, migratory birds and endemic aquatic species.

There are several remarkable geologic and biological components to the monument including several types of dunes and playa lakes. Gypsum sand, which is a rare hydrous form of calcium sulfate make up the ever changing dunes. This environment is of interest to researchers studying the processes of significant on-going geological processes in the

development of landforms, geomorphic and physiographic features. The gypsum sands also serve as a unique Mars analog. The monument preserves a portion of the Chihuahuan Desert ecosystem along with several unique white animal species.

Which features or aspects of the property do you believe qualify it for the World Heritage List?

Superlative scenic beauty: the white sand dunes are the subject of photographers' world wide, appearing in numerous books and magazines.

Unique scientific potential for ecotourism, research on hydrology, geologic processes, the discovery of new species and as a Mars analog

What are the important present or proposed uses of the property and how do they compare with the traditional or historic uses of it (e.g., to what extent and by what methods are natural resources being exploited)?

The present and proposed uses are education though guided tours and talks, public recreation including hiking, back country camping, picnicking, birdwatching and star gazing in addition to scientific research. These uses have a much lower impact on the resource than past activities. Past uses have included military maneuvers, missile and ordinance testing, mineral exploration and ranching.

2.b. History and Development of the Property

(select the one following category that best fits the property)

Natural property

What are the most significant events in history or prehistory that have affected the property? How have humans used or affected it?

Explanation: This discussion can include changes in the use of the property and its natural resources for hunting, fishing or agriculture, or changes brought about by climatic change, floods, earthquake or other natural causes.

The most significant events in the history of the monument include past geological processes, ranch and cattle grazing, and military activity followed by the establishment of the National Monument.

Past geological processes in the Tularosa Basin are the most significant events in the monument's history. These geological occurrences led to the formation of the gypsum dunes. The Pennsylvanian and Permian rocks in the mountains around the monument contain large quantities of gypsum. During the Permian, aridity increased and the seas covering the continent shallowed or withdrew completely at times, leading to deposition of shallow-water carbonates and gypsiferous evaporites. By far the bulk of these

evaporites are in the Yeso Formation found in the mountains around the basin. Moreover, the gypsum content in the Yeso thickens to the northeast, where the formation exceeds 4200 feet in thickness. Data suggests that much of the gypsum in the present day lake basin may have been flushed southward toward the low point of the basin at Lake Lucero. This was due to wide exposure of gypsum bearing rocks, the great thickness of gypsum and a broad catchment area that for surface and subsurface runoff. Although large amounts of gypsum may not be moving in drainages toward Lake Lucero at the present time, large amounts would have been dissolved and flushed into Lake Otero during Pleistocene glacial pluvials. Finally the evaporation and disappearance of Lake Otero following the last Pleistocene glaciation precipitated the gypsum which then became available for dune formation.

Ranching in the 1880s, change the vegetation in the basin. Overgrazing enabled the spread of shrubs and mesquite which led to soil erosion in some areas. Mesquite grows naturally in North America in the arid and semiarid lands of the Southwest, where it inhabits more than 82 million acres. Records of the earliest travelers and settlers suggest that mesquite has not substantially increased its geographical range in the southwestern United States, but it has greatly increased its density within that range. In the early 1800s miles of grasslands existed in the Southwest, characterized by extensive grassy plains, moderate grass-mesquite savannas, and dense mesquite mottes (clumps of isolated trees) in and around creeks and small bodies of water. Many of those same rangeland sites are now totally inhabited by mesquite. The rapid invasion of mesquite is attributed primarily to three causes: the overgrazing of grasslands by domestic cattle, the elimination of wildfires and several recorded droughts during the early 1900s. The grasslands in the Tularosa Basin were able to support large herds of cattle in the wet years of the 1880s. When the ranchers first started running cattle; in some places the grass grew as high as a horse's shoulder. In 1889, it is estimated that 85,000 head were mustered in the basin. The following years were ones of severe drought and the pastures never recovered from the consequent over-grazing and erosion which continued in many instances for 75 years or more. In the late 1800s, ranches and homesteads were established by families around the white sand dunes, these include properties owned by the Lucero, Garton, Pelman, Walter, McNew and Baird. The remains of these properties include house foundations, corrals, troughs, tanks, wells and windmills. The last occupied ranch within the monument was vacated in the 1950s. Many areas in the Tularosa Basin that were known historically to be rich grasslands are now characterized as desert scrub lands where creosote bush and mesquite trees predominate. The western portion of the monument above the lake shore is occupied by mesquite and creosote bush. This area does have considerable sheet wash erosion and the sediments are deposited in Lake Lucero. This does not directly threaten the dunes since the source of the gypsum is the shore line of Lake Otero. However, it may affect animal species that would otherwise inhabit a grassland environment.

The U.S. military began acquiring land in the basin as early as 1911, but most of the basin did not become military land until World War II. The establishment of White Sands National Monument in 1933 provided protection for the white gypsum sand dunes and the plants and animals that live there. Grazing and mineral exploration ceased.

Eventually military operations were also halted. Initially military dirt roads crossed the western portion of the park, debris and craters littered the landscape. In 1972, White Sands Missile Range removed 30,000 acres around Lake Lucero from targeting by intentional impacts. Today the surrounding military lands protect the monument from trespass and encroachment. The dirt roads have revegetated and White Sands Missile Range has worked diligently with the monument to fill old craters and clean up debris. Without the recognition of the dune's significance by the National Park Service the area would exist solely as a military test site, mineral commodity or a playground. Through the National Park Service, the potential for educating the public on the monument's natural resources is significant. Education and interpretation is a communication process that forges emotional and intellectual connections between the interests of the audience and the inherent meanings in the resource. The natural splendor of the dunes affords rich educational experiences for millions of visitors.

In summary, past geological processes created the vast gypsum deposits which are the source of the gypsum dunes. Ranching and cattle grazing changed the vegetation in the Tularosa Basin leading to erosion in places. The establishment of the National Monument then protected the area and preserved the dunes for future generations.

2.c. Boundary Selection

Propose a boundary for the property and explain why you chose it. Is the boundary reasonable on logical grounds, such as if it conforms to topography or landforms or (for natural areas) to the range of wildlife or (for cultural properties) to any historical boundary or defining structures (such as walls)?

The legal boundary of White Sands National Monument was selected as the boundary for the World Heritage Site nomination for management purposes. The white sand dunes extend on to Department of Defense lands, but their mission and land management practices are significantly different than the National Park Service.

Are all the elements and features that are related to the site's significance included inside the proposed boundaries?

Explanation: Careful analysis should be undertaken to insure that the proposal embraces the internationally significant resources and excludes most, if not all, unrelated buildings, structures and features.

YES: _____ NO: X _____

If no, please explain: a portion of the white sand dune field is on White Sands Missile Range and Holloman Air Force Base. White Sands National Monument contains a significant portion of the dune field and the shore line of Lake Otero which is the source of the white sand.

Are there any enclaves or in holdings within the property and, if so, do they contain uses or potential uses contrary to the conservation or preservation of the site as a whole?

YES: NO:

If yes, please explain: White Sands Missile Range has 8000 acres within the park's wildlife enclosure fence, these are excluded from the nomination. Legislation STAT. 2803, SEC. 2854, 16 USC 431 gives White Sands National Monument jurisdiction to manage those lands as National Park Service property. The land is in the process of being transferred to the National Park Service.

White Sands National Monument and White Sands Missile Range renewed an Interagency Agreement in 2006. "There is a mutual recognition of the respective missions of both agencies, and a mutual desire to continue the cooperative environment which has existed for nearly fifty years".

3. JUSTIFICATION FOR INSCRIPTION IN THE WORLD HERITAGE LIST

3.a. Criteria under which inscription is proposed

From the World Heritage criteria listed below, identify each criterion that you believe applies to your property and briefly state why you believe each criterion you have selected is applicable.

*Explanation: You may find the discussion under this heading in "Appendix A" to the **Guide to the U.S. World Heritage Program** to be helpful in completing this section. Please refer to a paper copy or follow the hyperlink.*

To be included on the World Heritage List, a site must be of outstanding universal value and meet at least one of these ten selection criteria in a global context:

- i. *represent a masterpiece of human creative genius;*

This criterion applies to the property I am proposing

Reason: _____

- ii. *exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design;*

This criterion applies to the property I am proposing

Reason: _____

- iii. *bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared;*

____ This criterion applies to the property I am proposing

Reason: _____

- iv. *be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history;*

____ This criterion applies to the property I am proposing

Reason: _____

- v. *be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change;*

____ This criterion applies to the property I am proposing

Reason: _____

- vi. *be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. (The Committee considers that this criterion should preferably be used in conjunction with other criteria);*

____ This criterion applies to the property I am proposing

Reason: _____

- vii. *contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance;*

X This criterion applies to the property I am proposing

Reason: At the northern end of the Chihuahuan Desert lies a mountain ringed valley called the Tularosa Basin. Rising from the heart of this basin is one of the world's greatest natural wonders, the glistening white sand of New Mexico. Here, great wave-like dunes of gypsum sand have engulfed 275 square miles of desert and have created the world's largest gypsum dune field. The quite solitude, vast landscape and changing light inspire personal reflection. Visitors from around the world seek out the beauty of the sands, many of them returning again and again. The popularity of the dunes is evident in the number of images in books, magazines and on the World Wide Web. The white sand dunes are an area of unique geology and remarkable natural beauty. The monument preserves a major portion of this gypsum dune field, along with the plants and animals that have successfully adapted to this constantly changing environment.

- viii. *be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features;*

X This criterion applies to the property I am proposing

Reason: Unique, ongoing geological processes of geomorphic changes and development can be seen at White Sands. The geologic history of White Sands began around 250 million years ago. The formation and development of the dunes is still dynamic today.

The gypsum that forms the white sand dunes was deposited at the bottom of a shallow sea that covered this area 250 million years ago. Eventually turned into stone, these gypsum bearing marine deposits were uplifted into a giant dome 70 million years ago when the Rocky Mountains were formed. Beginning 10 million years ago, the center of this dome began to collapse and create the Tularosa Basin. The remaining sides of the original dome formation now form the San Andres and Sacramento mountain ranges that ring the basin.

The Quaternary stratigraphy of the area is basically a record of the pluvial effects of the glacial periods, with the latest Pleistocene (Wisconsin) pluvation and de-pluvation being the most important in terms of surface geology. During glacial periods, weather in the Tularosa basin was cooler and wetter than today, with lower evapotranspiration. Lake Otero formed and water levels were maintained both by greater groundwater infiltration and greater fluvial runoff into the Tularosa Basin. Interglacial periods, especially the most recent have been drier. The dunes at White Sands National Monument probably resulted from the effects of the drying and warming which has occurred since the last glacial retreat about 10,000 years ago, with the most significant events beginning about 7,000 years before present. It was during the last 10,000 years that Lake Otero dried up, precipitating the gypsum that was mobilized at some later date to form the present-day dune fields.

The dunes at the White Sands National Monument probably have resulted from the effects of the drying and warming which has occurred since the last glacial retreat about 10,000 years ago. Experimental thermoluminescence dating has produced some tentative dates for the park's recent geologic history. For quartzose fluvial sediments near the base of the Otero gypsum deposits a date of about 14,000 years was obtained, which places the Otero Evaporite sediments solidly in the late Pleistocene. In the center of the park, in the picnic area a date of 7,000 years before present was obtained from a basal clay layer that underlies the bedded gypsum. This corresponds to the onset of a regional arid event at 7,000 years ago. Additionally, a date of 6,500 years before present was obtained for a gypsite encrusted parabolic dune arm that extends northeastward from South Lake Lucero to Point of Sands. The latter date fits well with the altithermal of Antevs. This was probably the first major eolian event that can be potentially tied to the present dune field at White Sands.

Other interesting dates obtained include an age of approximately 2,100 years for dune sediments underlying the Alkali Flat near the terminus of the Alkali Flat wilderness trail. A modern dune and pedestaled dune yielded comfortably modern dates of 820 and 440 years ago. Data suggest an initial dunefield formation event at the Altithermal 8,000-5,000 years before present. The question of the precise age of the dunefield at White Sands remains open, however all evidence points to an age younger than 7,000 years ago, with dunes perhaps considerably younger.

When the dominant wind from the southwest blows across the Pleistocene Lake Otero shoreline, finer silts and clays are blown away, a process called deflation, leaving the crystals exposed. Such weathering breaks the crystals down to the size of sand grains which can be moved by the dominant wind. Sand can only be moved by strong, steady winds. The air must be moving at least 15 miles per hour to be able to pick up sand grains. In the Tularosa basin, it is primarily between February and April that the winds are strong enough. These winds are called unidirectional winds because they always move in the same direction, from the southwest to the northeast. As the wind blows, it pushes the sand ahead of it, so individual dunes are slowly moving to the northeast. Even very strong winds can't lift the sand any higher than three feet above the ground. As the wind blows, it lifts small sand grains a few feet off the ground, and then drops them. When they hit the ground, they bump into other sand grains and cause them to jump up and be caught by the wind. It's almost as if the sand is playing leap-frog, jumping and bumping along. This kind of jumping movement is called saltation. How fast a sand dune moves depends on a number of things. The speed of the wind is a big factor. Wind that is blowing 45 miles per hour will move more sand than at 15 miles per hour. The size of the dune is also important. Smaller dunes with less sand move much more quickly than large ones. The vegetation also plays an important role. The dunes get caught on the plants that grow in the basin, and that slows them down.

There are four types of dunes at White Sands National Monument. Most of the freely moving dunes at the monument are of the barchanoid type that develops a major slipface transverse to a single dominant wind direction. The dunes move in that direction which is from the southwest at White Sands. Another type of dune which has transverse affinities is the dome dune. Dome dunes, however, have no slipfaces most of the time. They have long been considered embryonic forms that evolve downwind into barchanoid types with slipfaces. In addition to freely moving dunes, White Sands also has many tracts of dunes partially anchored by vegetation. Parabolic dunes have an actively migrating central mass and long arm that extend upwind, as opposed to shorter arms of the barchan that extend downwind. Another unusual dune type at White Sands is the lunette dune, so named because of its shape when associated with small lakes. Lunette dunes form in the lee of lakes, and assume the shape of the shoreline. Most of the lunettes at White Sands appear to be older than the present active dune field, and have been somewhat reduced by weathering.

The interdunes at White Sands, like the dunes themselves, exist in great variety, with a wide range of sedimentary deposits at or just below the surface that have been laid down in this environment. The saturated ground water table is often within a few feet of the surface of the interdunes, and the range of salinities is quite large from place to place or season to season. Ground water with the lowest salinity is found just inside the dunes along the eastern boundary of the dune field. The high water table in this area of the interdunes supports a wide variety of plant life acting like small oases. This aspect of the interdunes environment, along with environments created by the dunes themselves, creates a wide variety of sub-environments. Much of the flora and fauna of the White Sands live in the interdune areas because they have moisture and vegetation, and are sheltered from the wind to a greater extent than on the open and exposed sands of the dunes. It is important to understand the significance of the interdunes at White Sands in order to better appreciate how the flora and fauna of White Sands have adjusted.

In summary, the geologic history of White Sands began around 250 million years ago and has not ceased. At the monument there are dynamic on going geological processes of geomorphic changes and development. The formation and development of the dunes is as constant as the wind. More recently these unique terrestrial dunes have served as a Mars analog for out of this world research.

- ix. *be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals;*

X This criterion applies to the property I am proposing

Reason: Reason: Since the White Sands dune field came into existence only after the end of the last glaciation, 10,000 years ago, it provides an opportunity to study organisms in a natural selection regime of recent origin. A number of endemic white animals have been identified in the white dunes. At least 12 species are permanently white, and another three are variable, paling against a white substrate. These species include arthropods, amphibians, lizards and rodents. A major starting point for speciation is the separation of populations by a geographic barrier that prevents continuing gene flow. No such barrier separates the white dunes from adjacent dark colored soils. Thus the White Sands ecotone provides a readily accessible site for biologists to study possible in progress speciation in the absence of a physical barrier to gene flow. This is a subject of considerable current interest owing to the introduction of powerful molecular techniques into the field of evolutionary biology for phylogenetic analysis.

The lizards of White Sands are particularly striking with respect to dorsal coloration. All three species have light populations in the heart of the dunes and dark populations outside the dune habitat, with the variably colored animals on region of transition at the margin of the dunes. Molecular data reveal different histories for the three species. The bleached earless lizard is lighter in color and better substrate-matched than either the Cowles prairie lizard or the little striped whiptail. Furthermore, this corresponds exactly to observed levels of gene flow; there is more gene flow between dark soil and white sand populations for the Cowles prairie lizard and the little striped whiptail than for the bleached earless lizard. This suggests that the degree of genetic isolation of dune populations may be very important in determining the outcome of natural selection. Interestingly, there has been recent or current gene flow between dramatically different color morphs in two of the three species indicating that natural selection can generate phenotypic diversity despite ongoing interaction between populations. This suggests the operation of extremely strong natural selection at the White Sands ecotone which supports the model of ecological speciation. A number of different mate-choice experiments were conducted to see if White Sands females preferred to mate with light males or dark males. In fact, light females did have a preference for light males. Furthermore, there are a number of morphological differences between White Sand and dark soil populations of *H. maculata*. White Sand populations are unique in the shape of their bodies, their heads and their feet. These morphological differences could be further specializations to the sandy environment. Again, these results do not necessarily mean that White Sands bleached earless lizards should be considered a new species, but the extensive differences between dune and non-dune populations suggest that natural selection at White Sands could lead to reproductive isolation. The ecological research done at White Sands reinforces the idea that ecotones are especially important in generating biological diversity and should be priorities for conservation.

The geological development of isolated desert features, such as dune systems and dry lakebeds, provide unique habitats that subsequently harbor unique organisms.

These endemic organisms are not only of interest for conservation purposes, but are potentially important indicators charting the course of environmental changes leading to desertification. One such endemic organism that may provide significant clues to past environments is the monotypic spider genus *Saltonia*. This genus *Saltonia* is apparently restricted to salt-crust habitats of dry or intermittent lakes and rivers. This extreme habitat restriction allows for the testing of a hypothesis suggesting that paleoriver drainages played an important role in the current distribution of *Saltonia incerta* and should thus be reflected in the biogeographic history of the group. This assumes that the spiders were dispersed from one salt lake to the next through riverine corridors connecting these lakes during the Pleistocene, and that there is currently little or no gene flow between the now isolated populations. Previously known from only two localities, it has now been found at several salt flats in southern California and northern México, and a species new to science exists at White Sands National Monument.

Almost nothing is known about the insects of the gypsum white sands environs of White Sands National Monument. The efforts to achieve World Heritage Site status for the Monument are of high merit, and it is important that the dearth of information about insects should not be a hindrance. The case for the value of insects at White Sands National Monument is laid by first giving facts which state the critical existence of insects in the environment. The entire biota of White Sands National Monument, especially the plants and vertebrate fauna so highly treasured would immediately collapse without insects.

Insects are the dominant life form on Earth. Insects account for more than half of all the species of plants and animals on Earth. The biomass of insects exceeds the biomass of all other land animals. For example the biomass of two groups of insects, ants and termites combined, makes up to 33 percent of all terrestrial animals. Although there are lots of insects in terms of species and biomass, most species have distinct habitat or seasonal preferences, thus the specialized habitats of the gypsum white sands will harbor species found nowhere else on Earth.

White Sands represents a unique environment, found nowhere else in the world. Such unique properties create unique environments for plants and animals unlike anywhere else. A large flora is known to be restricted to gypsum soils of the Chihuahuan Desert, having evolved unique adaptations to live on gypsum soils.

The invertebrate fauna of Chihuahuan Desert gypsum soils and dunes is poorly known. Chances are high that like the flora, there is a large and unique invertebrate fauna associated with gypsum soils. However, unlike vascular plants, the invertebrates have not been well studied, and many species likely remain to be discovered and described. White Sands National Monument probably supports an unknown, but likely substantial biodiversity of gypsophilic arthropods that make the dune system a very special and unique place. Cary (personal communication 2007) reports 50 species of butterflies as residents of

the gypsum white sands environs. Metzler's experience, and calculations based on known models, indicates that the species richness of moths at White Sands National Monument should be about 1,000 species. White Sands National Monument presently harbors at least seven species of undescribed moths. Consider the popularity that one species of endemic camel cricket gives to Carlsbad Caverns National Park, yet we already know of two endemic camel crickets at White Sands National Monument, but the public never hears about them. All other national parks and monuments in the Chihuahuan Desert represent widespread environments. White Sands National Monument is unique in that it represents a truly unique local environment and associated plants and animals.

Once again we see a rich potential for biological research at the White sands, since work has hardly begun on the cataloging of invertebrate species, organisms that are particularly valuable to basic ecological and evolutionary research, as well as for instructing conservation policy.

- x. *contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.*

X This criterion applies to the property I am proposing

Reason: White Sands National Monument lies in the northern portion of the Chihuahuan Desert, which covers a portion of the United States and Mexico. At White Sands National Monument species of animals occur that can be found no where else in the world. The white sand habitat supports many of the Chihuahuan Desert species in addition to 12 white animal species, including two rodents, three lizards, one amphibian, four insect, and two arachnid species which have permanently changed their color to match the white gypsum dunes.

White Sands National Monument provides excellent habitat diversity for a wide range of avian species; habitats include desert plains, playa lakes, water corridors, cottonwood groves, uplands and a gypsum dune field. Because the monument is surrounded by military land, it is free from urbanization and its remoteness allows it to be an excellent sanctuary for wildlife. Lake Lucero and surrounding grass and shrub land provide important habitat for migrating birds and wintering waterfowl in the Central Flyway. The large diversity of birds found in the monument may be attributed to its location on the central flyway, the presence of Lake Lucero and the monument's proximity to the Rio Grande River. The 2006 seasonal inventory of birds in riparian habitats found that White Sands had three obligate riparian species and 12 riparian dependent species.

World Wildlife Fund designated the Chihuahuan Desert as one of 19 priority landscapes in the world. It is considered one of the most biologically significant deserts. The Chihuahuan Desert landscape and ecology are rapidly changing as a result of land use by an ever increasing human population. The desert's habitats, plants and animals are rapidly vanishing, and a water crisis threatens the survival of wildlife as well as people. The Chihuahuan Desert is one of the most biologically rich and diverse deserts in the world, rivaled only by the Namib-Karoo of southern Africa and the Great Sandy Desert of Australia. It stretches nearly 250,000 square miles from the Mexican plateau into southeast Arizona, across New Mexico and West Texas. It is framed by the Rocky Mountains and the Sierra Madre system.

According to the Chihuahuan Desert Education Coalition, the Chihuahuan Desert is the most biologically diverse desert in the Western Hemisphere and one of the most diverse arid regions in the world. The eastern boundary of the Chihuahuan Desert is one of the oldest and richest centers of plant evolution on the North American continent.

The Nature Conservancy considers the Chihuahuan Desert a center of cactus diversity, many of which can be found nowhere else on Earth, with more than 400 species. In addition, the region supports a tremendous variety of bats, migratory birds and endemic aquatic species.

The Center for Biological Diversity is deeply committed to protecting desert wilderness in North America. They focus their desert programs on the protection of endangered species and imperiled watersheds, as well as high-value ecological areas urgently threatened by urban sprawl. The Chihuahuan Desert's diverse habitats provide the kaleidoscope of textures and colors that shape its unique landscapes. Mule deer, pronghorn and kit fox roam the vast grasslands of the northern desert. In the desert scrub, roadrunners scurry after earless lizards while golden eagles search among the agave and creosote for blacktailed jackrabbits. Forests of yucca and agave create images of unearthly beauty. Overall the magnificent landscape is threatened by unsustainable land use by an ever increasing human population, water misuse and mismanagement, overgrazing by cattle and goats, and a general lack of knowledge regarding the desert's ecological importance.

Although the Chihuahuan Desert features of Carlsbad Caverns National Park and Big Bend National Park are spectacular in their own right, similar features can be found throughout the world. In comparison, the sheer size of the gypsum dune field of White Sands can be found no where else on earth. In terms of biological diversity and ecological processes, White Sands may hold the greatest scientific value for the entire Chihuahuan desert, the continental 48 states, and much of the world. Although Big Bend National Park contains 2,233 documented species overall in comparison to 1,424 at Carlsbad Caverns National Park and 563 at White Sands, the Big Bend area has had far more research and surveys. The

figures are miss leading, as scientist and researchers discover White Sands new species are being found almost daily.

White Sands is one of the few places in the world where biodiversity is steadily increasing as organisms rapidly adapt and evolve to this truly unique environment. In accordance with comparative analysis for the World Conservation Union and World Heritage lists, White Sands displays text book examples of speciation, adaptation, and endemism that can be seen in the plants and animals that inhabit the monument. For this reason, White Sands has been referred to as America's Galapagos Desert by the researchers and managers that have worked here.

The beauty and uniqueness of White Sands and its amazing geology has been well known for years, but less known and perhaps most unique and important is the rapid adaptation being carried out by species of almost every class animal. Unlike anywhere else in the Chihuahuan desert, White Sands has a species from every class of vertebrate and many invertebrates that have adapted to this rapidly changing environment.

White Sands is one of few places on earth where the secession of rock, to sand, to dunes, and back to rock again can be readily seen. At every stage along this process new micro habitats and several ecotones have been created, supporting a high degree of endemic species. Around the playa lake, there is a spider that lives under the millions of selenite crystals that cover the ground. In the grasslands that grow on the gyp-soils, there are several unnamed species of grasshoppers that are very light in color. White Sands has a dramatic showcase for evolution in action that allows important questions to be asked about the role of natural selection in generating biological diversity.

At first glance much of White Sands may appear bleak and devoid of vegetation, but a closer look will reveal numerous well adapted plants with a high percentage of endemic species most distinctive from any other plants on earth. It is very likely that many of the adapted animal subspecies are on their way to becoming new species like the numerous gypsophilic plants that have evolved to this unique environment. The plants at White Sands have adapted to mineral and salt levels that under normal conditions would kill other plants. Considerable speciation has occurred in connection with the limiting edaphic conditions of gypsum soils. The biological aspects of gypsum endemism constitute one of the most exciting stories of modern evolutionary and floristic biology.

With over 30 endemic plants and animals, White Sands is likely to have the greatest level of endemism per acreage within the Chihuahuan desert. Although Sky Islands are common throughout out the Chihuahuan desert and around the world, nowhere else on earth is there a gypsum island the size of White Sands. The size and unique properties of the gypsum sand and crystals have allowed rapid adaptations to occur in response to this very unique ecotone, steadily

increasing the biodiversity at White Sands and within the Chihuahuan desert. In the last three years alone over 10 possible new species have been discovered at White Sands. This includes seven new moths, one spider, one wasp, three grasshoppers, and several rotifers. All these new animals appear to be well adapted in behavior and appearance to the landscape of White Sands. Although gypsum deposits are very common through out the world, there is nowhere else on earth of equal size to support the same level of endemism, White Sands is one of the few land features that can be identified from space.

In summary, White Sands National Monument preserves 144,000 acres of truly unique habitat within the Chihuahuan Desert in addition to several species found no where else in the world. The monument provides important habitat for three obligate riparian bird species and 12 riparian dependent species alone. Overall the monument and the Chihuahuan Desert it occupies are considered to be highly significant by several renowned conservation groups.

3.b. Proposed statement of outstanding universal value

Based on the criteria you have selected just above, provide a brief **Proposed Statement of Outstanding Universal Value** summarizing and making clear why you think the property merits inscription on the World Heritage List. If adopted by the World Heritage Committee, the statement “will be the key reference for the future effective protection and management of the property.”

*Explanation: This statement should clearly explain the **internationally** significant values embodied by the property, **not** its **national** prominence.*

*“**Outstanding Universal Value**” is formally defined as “... **cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance to the international community as a whole.**”*

The geology and biology at White Sands National Monument is internationally unique. The monument in southern New Mexico preserves the world’s largest gypsum sand dune field, covering 275 square miles of the Chihuahuan Desert. The Chihuahuan Desert in itself is one of most biologically rich and diverse deserts in the world. White Sands is also significant for scientific research, one of the key elements for which it was established. Of particular interest to science is the evolution of animal species at the monument and the geology as a Mars analog.

Unlike the common lake and seashore quartz sand dunes, gypsum dunes made up of wind blown crystals of calcium sulfate are rare. Gypsum usually dissolves in rain water or snow melt and is carried away in streams and rivers. The monument is located in a basin where the gypsum has collected for thousands of years. Smaller gypsum dune fields are found in Texas and Utah. Mexico has a similar but smaller, and seriously disturbed,

gypsum dune field. Australia also has gypsum deposits, some of which occur in the form of dunes, but these are available for commercial exploitation.

White Sands is an internationally significant place for studying evolution and the search for new species. The stark white gypsum dunes are geologically recent, having been formed since the end of the last glaciation. This provides an opportunity to study organisms in a recently changing natural selection regime. A number of endemic white animals have been identified in the white gypsum dune field. At least six species are permanently white, and another three are variable but turn white on a white substrate. Included species are arthropods, lizards, amphibian, and rodents. No geographic barrier separates the white dunes from adjacent dark colored soils. Therefore, any local adaptation to White Sands is due to natural selection rather than historical isolation. This is provocative because it challenges many of the assumptions of current speciation theory.

Many desert features, such as dune systems and dry lakes, provide a unique habitat type found nowhere else in the world, and subsequently harbor organisms also found nowhere else in the world. These endemic organisms are not only of interest for conservation purposes, but are potentially important indicators of environmental changes which have occurred throughout history in this region. One such endemic organism that may provide significant clues to past environments is the monotypic spider genus Saltonia. This species is apparently restricted to salt-crust habitats of dry or intermittent lakes and rivers. Previously known from only two localities, it has now been found at several salt flats in southern California and northern México, and a species new to science exists at White Sands National Monument.

Terrestrial desert sites provide excellent and affordable environments in which to carry out scientific research relevant to the exploration of the Moon and Mars. White Sands is one of the few sites internationally where Mars analog research is being conducted, other sites include Ellesmere Island, Canadian High Arctic and Rio Tinto, Spain. Extensive sulfate deposits have been discovered recently at multiple locations on the surface of on Mars. White Sands also has the common mineral gypsum, a hydrous form of calcium sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), rarely found in the form of sand. The extent and purity of this deposit is sufficient to make it a highly unusual, if not a unique geological formation. White Sands is significant for understanding the geologic history at Eagle Crater on Mars. It is now assumed that water was once present in Eagle Crater due to the presence of sedimentary structures like ripple cross stratification, along with salts and minerals that form through water evaporation. Sedimentary structures and minerals formed by surface and groundwater at White Sands may resemble those on Mars. Any similarities in the features between the two sites will help in understanding the paleoenvironmental conditions during the formation of sedimentary rocks in Eagle Crater on Mars.

Data from Mars Exploration Rovers and instruments in orbit indicate a more active recent hydrologic cycle than previously recognized. Complex water and rock interactions appear to be driven by eolian weathering, winter frost and ice accumulation and summer melt-water discharge on modern Mars. White Sands National Monument is a critical site

to study these types of processes and to test hypotheses regarding formation and alteration of Martian regolith. The following processes are poorly understood and need to be scientifically addressed: 1) formation and transformation of sulfate-rich deposits in lakes and playas from closed-drainage basins, 2) erosion of evaporitic crusts and eolian grain transportation at sites of gypsum dune formation, 3) early diagenesis in gypsum dunes under arid and semi-arid climate condition, and 4) local and regional influences of volcanism on sulfur cycles.

Images from the Mars rover Opportunity, show patterns of cracks across the surface of boulders and outcrops. Some of these cracks are associated with long, thin fins that protrude from the surface. Such features look very similar to cracks and fins that form on the sulfate-rich sands at White Sands National Monument. The cracks at White Sands only form and grow in damp sand, especially during the wet months of the winter. The fins are formed when water seeps into cracks in the sand, carrying minerals with it. The water evaporates away, leaving behind those minerals which are exposed as the wind blows sand away. Windblown material sticks to the exposed fin, making it larger and stronger. If the cracks and fins seen by the Opportunity rover on Mars are formed in the same way as the features at White Sands, it would provide evidence for water at the surface of Mars away from the polar ice caps. Life does not persist in the absence of liquid water on earth, so astrobiologists are interested in finding the existence of water on the surface and subsurface of Mars.

The internationally significant values of White Sands National Monument are found in its geology and biology. The monument preserves the world's largest gypsum sand dune field and a unique portion of the Chihuahuan Desert in itself is one of most biologically rich and diverse deserts in the world. White Sands is also significant for its potential for scientific research on evolution of animal species and the paleontology of Mars.

Natural property

For example, a natural World Heritage Site may be a unique existence of a type of habitat or ecosystem. It may comprise assemblages of threatened endemic species, exceptional ecosystems, outstanding natural landscapes or other natural phenomena.

3.c. Comparison of proposed property to similar or related properties (including state of preservation of similar properties)

Please provide a statement explaining how the property being proposed compares with all other similar or related properties anywhere in the world, whether already on the World Heritage List or not.

*Explanation: Examples of questions that may be useful to consider include whether the proposed property is part of a series or sequence of similar sites belonging to the same cultural grouping and/or the same period of history. Also, are there features that distinguish it from other sites and suggest that it should be regarded as **more, equally** or **jointly** worthy than they are? What is it that makes this property intrinsically better than others and qualifies it for the World Heritage List? For example, does it have more features, species or habitats than a similar site? Is the property larger or better preserved or more complete or less changed by later developments?*

It will be especially helpful if specific reference can be made to a study placing the property in a global context. The absence of comparative information may indicate that the property is either truly exceptional (a difficult case to prove) or that it lacks international importance. If the results of the comparative review reveal that multiple sites possess roughly comparable merit and may possess international significance as a group, you may wish to recommend that more than one site be proposed, as a serial nomination or as a joint nomination by the United States and another country.

Also please make note of any major works that evaluate the property in comparison to similar properties anywhere else in the world.

White Sands National Monument in southern New Mexico preserves the world's largest area of snow-white gypsum sand dunes covering 275 square miles of the Chihuahuan desert. Unlike the common lake and seashore quartz sand dunes, gypsum dunes - made up of wind-blown crystals of calcium sulfate are rare. Smaller gypsum dune fields are found in Texas and Utah. Mexico has a similar but smaller, and seriously disturbed, gypsum dune field. Australia also has gypsum deposits, some of which occur in the form of dunes, but these are available for commercial exploitation.

The dunes of the White Sands National Monument are wind carried deposits swept from the ancient dry lakebed of the Tularosa Basin. These eolian deposits are exceptional not only in their extent, but in being almost entirely of gypsum sand. Since gypsum is soluble, such deposits do not usually accumulate, but at White Sands there are no streams or rivers to carry it away.

The unusual geology of the monument makes it an exceptional place to conduct geologic research. Project on hydrology, sulfates, dune movement and White Sands as a Mars analog are under way. It is also home to an assemblage of unique plant and animal species. Twelve animal species, including two rodent, three lizard, one amphibian, four insect, and two arachnids have permanently changed their color to more closely match the light substrate of the dunes. Thus the gypsum dune field, much like isolated island environments, offers opportunities for biological research in such fields as physiological adaptation and evolution.

The singular environment of the dunes is embedded in the larger environment of the Chihuahuan Desert, designated by the World Wildlife Fund as one of 19 priority landscapes in the planet. It is considered one of the most biologically significant deserts

in the world, rivaled only by the Namib-Karoo of southern Africa and the Great Sandy Desert of Australia. The protection of the Chihuahuan Desert at White Sands is also a priority for the Center of Biological Diversity. The awe-inspiring scenery of the dunes coupled with these unique natural features makes it a very popular destination for ecotourists from around the world.

The uniqueness of the White Sands National Monument is exemplified by comparison with other regions where gypsum deposits are found. The Guadalupe Mountains National Park in Texas lies at the foot of the escarpment of the Guadalupe Mountains. Winds whip across the surrounding salt flats and pick up crystals of gypsum. When the breezes hit the mile high wall of the mountains, they deflect upward and dump their load to form a dune field approximately three miles long and a mile wide. Plant life stabilizes much of the five thousand acres of white sand. The dunes of the jettisoned sand that rise from the desert floor are similar, though much smaller in extent, to those of the White Sands National Monument in neighboring New Mexico.

Knoll, Utah, has gypsum sand dunes located on the eastern margin of the Great Salt Lake Desert. A large proportion of the Salt Lake Desert is used by the military; Hill Air Force Base to the north and the Wendover Gunnery Range to the south. The gunnery range has used the area for weapons testing over the past 40 years. A portion of the dunes are accessible along Interstate 80. Here gypsum crystals form in the top layer of the moist salty clay that forms the desert floor. As the clay dries, the crystals are blown by the wind into dunes. The sand is formed around mineral particles and fecal material. The oolitic sand is a concretion, not composed of grains. Unlike the gypsum of the White Sands Monument and Guadalupe Park, the gypsum here is not protected; it can be collected and removed by the public.

Bolsón de Cuatro Ciénegas, Coahuila, México, is a naturally closed 425 square mile intermountain basin. Gypsum salts blown from evaporating lakebeds form a 1,977 acre dune field. Active dunes up to 30 feet high encroach upon streams, posos or pools, older dunes and the surrounding plains. The gypsum was mined for decades by the Proyoso Company. Consequently the pure gypsum dunes of Cuatro Ciénegas were on the verge of disappearing - today, only approximately 15% of the original dunes remain. In November 2000, with The Nature Conservancy's support, Prelature Noreste purchased Rancho Pozas Azules (Ranch of the Blue Pools), a 7,000 acre ranch harboring more than 130 of the valley's 450 desert springs. The acquisition of Rancho Pozas Azules marked the first ever conservation easement in the state of Coahuila and the largest private land conservation purchase in Mexico's history. It is now owned and managed by Prelature Noreste as a nature preserve. Currently, the partners are working to protect two properties north of Rancho Pozas Azules, which include significant numbers of pools.

Besides the mining operations, livestock grazing and agriculture have had a serious impact on the land. The availability of ground water has lured many farmers to the valley, even though the heavily saline water is of poor quality. Water has been over-exploited and several species of fresh water fish have become extinct.

Gypsum deposits in Australia fall into three classes, salt lakes or playas, coastal basins and sequences in ancient sedimentary rock. The largest reserves of gypsum are those associated with coastal basins and sedimentary deposits, but the majority of the mined gypsum deposits in Western Australia are associated with salt lakes. An episode of high lake levels prior to the last maximum glaciation has been identified at many localities in eastern Australia. Similar events have been recognized at playa lakes in central Australia, where gypsum dunes along playa margins formed during one or more episodes of high groundwater discharge, with a large influx of calcium sulphate. Millions of tons of gypsum are mined and shipped in Australia each year. The agricultural use of gypsum alone comprises some 20 to 25% of Australian's consumption.

Australia does have a number of National Parks, though the gypsum dune environment does not appear to receive the same level of protection that is given at White Sands National Monument or Guadalupe National Park. For example, Innes National Park is located within the Innes Environmental Region is described as an undulating plain with dunes, salt lakes and coastal cliffs. At the time the park was proclaimed, the major gypsum lakes were excluded from dedication on the basis that they contained mineral resources that should remain available for mining.

Additional sites in Australia with dunes include Willandra Lakes and Uluru. The Willandra Lakes Region covers 593,052 acres of a semi-arid landscape in far south-western New South Wales. The shores of Willandra Lakes have crescent-shaped dunes called lunettes, formed by quartz sands and pelletised clay, blown from the lakes by westerly winds. The dune-building environment prevailed during the Pleistocene starting more than 50,000 years ago. White Sands National Monument also has lunettes, however they are much younger and composed of gypsum instead of quartz and clay.

The area around Uluru also has dunes. Uluru is an isolated remnant left after the slow erosion of an original mountain range. It is a great block of up tilted sandstone in the heart of Australia's Outback. The huge vertical slab extends far below the surrounding plain. The gently sloping sand plains around Uluru are composed of medium textured red sandy loams and very coarse siliceous sand. Geologists have found that these dunes have remained in their present position for 30,000 years. However the crests of the dunes have looser sand and shift with the wind. The dunes at White Sands are much younger and more active.

Other areas with dunes to consider are Banc D'Arguin, Mauritania, Air and Tenere National Park and the Saharan desert of Tenere, Niger, and Tassili n'Ajier, Algeria. Banc D'Arguin, provides an example of a coastal desert between the Sahara and the Atlantic Ocean. It is a vast area of islands and coastline, largely composed of windblown sand of Saharan origin, together with a large expanse of mudflats. Coastal deserts generally are found on the western edges of continents near the Tropics of Cancer and Capricorn. They are affected by cold ocean currents that parallel the coast. Because local wind systems dominate the trade winds, these deserts are less stable than other deserts. Winter fogs, produced by upwelling cold currents, frequently blanket coastal deserts and block solar radiation. Coastal deserts are relatively complex because they are at the juncture of

terrestrial, oceanic, and atmospheric systems. Crescent-shaped dunes are common in coastal deserts, with prevailing onshore winds. Banc D'Arguin is notably a wildlife preserve. In comparison, White Sands National Monument also has crescent-shaped dunes in addition to several other types. Although the monument protects desert wildlife and migrating birds as does Banc D'Arguin, it maybe more significant for the evolution of new white colored species.

Air and Tenere National Park, Niger, comprises two geomorphic units: the Air mountains rising above a rocky plateau, and the Saharan sand dunes and plain of the Tenere to its east. The eastern three-fifths of the reserve are located in the Tenere desert, one of the largest sand seas in the Sahara. Several sand dune fields occur piled against the massifs by the prevailing north-easterly winds. They are some of the highest sand dunes in the Sahara, standing approximately 980' tall. The Sahara desert contains complex linear dunes and fields of small mobile barchan dunes. The Tenere is arid, with an extremely hot and dry climate and virtually no plant life. White Sands contains mobil linear transvers and barchan dunes. It is the gypsum at White Sands that make it particularly unique.

In Algeria, the Tassili n'Ajjer is known for its plateau of chasms. The Park comprises two geomorphic units: sandstone plateau and mountainous volcanic ridge. The plateau is hyperarid, very exposed and barren. It is part of an ancient sandstone layer with extremely broken terrain towards the north. Its north-facing cliffs are cut by several deep gorges and steep-sided watered valleys running northward into sands. The red to black-weathered sandstone has been deeply eroded into forests of 65-98' pillars like ancient ruins and rises above the shifting dunes on the edge of the Sahara. At Tassili n'Ajjer the forest of rocks or pillars appear to be the significant geological feature of the area and not the sand dunes.

One can see from the brief survey above that the gypsum dunes at White Sands National Monument are exceptional. The monument preserves the world's largest gypsum dune field. These dunes are protected; the removal of sand and the disturbance of plant and animal species are prohibited. Only the smaller dune field at Guadalupe Mountains is preserved to the same degree.

3.d. Integrity and/or Authenticity

Explanation: As with a site's international significance, the clear intent of this requirement is that a World Heritage Site's authenticity or integrity must rise to a superlative level. Thus, for example, it is quite important to understand that reconstructions of historic structures or sites or largely restored ecosystems will usually be disqualified from inscription in the World Heritage List.

Natural property

Are there intrusions by non-native animals or plants and are there any human activities that could compromise the property's condition?

YES: X NO: _____

Comment: White Sands does not have intrusions by human activities other than controlled access for tourist and scientist, primarily because the entire monument is fenced and surrounded by secured military lands. Prior to being fenced in 1996, the monument had a population of African Oryx. These exotic animals have been removed. The monument has a number of non-native plant species including Russian thistle, African rue and Tamarisk. The Tamarisk presently holds the highest threat to White Sands. It is highly adapted to arid climates. It thrives in very saline and nutrient-poor soil. During the spring Tamarisk can grow as much as one foot per month. It spreads readily by seed and by root, trunk, and branch sprouts. Tamarisk can usually out-compete native plants for water. A single, large tamarisk can transpire up to 300 gallons of water per day. In many areas where watercourses are small or intermittent and tamarisk has taken hold, it can severely limit the available water, or even dry up a water source. Tamarisk can grow in salty soil because it can eliminate excess salt from the tips of its leaves. When the leaves are shed, this salt increases the salinity of the soil, further reducing the ability of native plants to compete. Because of its ability to spread, its hardiness, its high water consumption, and its tendency to increase the salinity of the soil around it, the tamarisk has often completely displaced native plants in wetland areas. The high ground water table in the monument allows Tamarisk to grow virtually any where.

If efforts are being made to conserve or restore a site or ecosystem, what is their nature and are scientifically directed measures being used? If the site comprises a unique ecosystem or habitat values, is the area proposed of sufficient size and configuration to contain as complete a representation of an ecosystem or habitat as is practicable or reasonable?

Nature of conservation or restoration measures: The park employs a biologist and with the help of the Chihuahuan Desert Exotic Plant Management Team, the tamarisk is being removed from White Sands. In the fall of 2006 the federal agencies within the Tularosa Basin met at White Sands National Monument to explore ways to cooperatively treat exotic plants including Tamarisk. Holloman Air Force Base located to the east of the monument completed aerial spraying for Tamarisk. Tamarisk growth within the park is not increasing. The ecosystem is suitably intact to support the monuments species and their habitats.

Proposed area is sufficient:

YES: X NO: _____

Comment: The monument is comprised of 143,733 acres of dunes with shrub and grasslands, approximately 5,000 acres contain Tamarisk.

4. STATE OF PRESERVATION AND FACTORS AFFECTING THE PROPERTY

4.a. Present state of preservation of the property

Natural property

What is the present state of conservation of the property (including its physical condition and conservation measures in place)?

White Sands is conserved through its protections as a National Monument. There is no mining, agriculture, ranching, public hunting or public off road driving. The monument is only accessible from an eight mile loop road and three trails. Tourist may hike in any direction but the vast majority does not walk more than a mile from the access road.

Are there data on species trends or the integrity of ecosystems and are there any on-going or planned interventions to restore natural conditions (e.g., to restore altered topography or manage invasive species and/or restore native ones)?

YES: _____ NO: X

Comment: Data on species trends and the integrity of the ecosystem are not yet available. In 1999, the National Park Service launched the Natural Resource Challenge, a five year program designed to strengthen natural resource management in the nation's national parks. The single biggest undertaking of the Challenge was to expand ongoing park inventory and monitoring efforts into an ambitious comprehensive nationwide program. The Service wide Inventory and Monitoring (I&M) program was introduced to 270 parks identified as having significant natural resources. Under this program, parks have been organized into 32 networks to conduct long-term vital signs monitoring. Each network links parks that share geographic and natural resource characteristics, allowing for improved efficiency and the sharing of staff and resources.

The Service-wide goals for vital signs monitoring in the National Park Service are:

- Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
- Provide early warning of abnormal conditions and impairment of selected resources to help develop effective mitigation measures and reduce costs of management.
- Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
- Provide data to meet certain legal and congressional mandates related to natural resource protection and visitor enjoyment.

- Provide a means of measuring progress towards performance goals.

The intent of the NPS monitoring program is to track a subset of valued resources and indicators of overall ecosystem condition, known as "vital signs." The vital signs for White Sands National Monument have been identified but most are not yet monitored, with the exception of depth to ground water.

4b. Factors affecting the property

If there are known factors likely to affect or threaten the outstanding universal values of the property or there any difficulties that may be encountered in addressing such problems through measures taken, or proposed to be taken, please use the following is a checklist to help in identifying factors.

(i) Development Pressures (e.g., encroachment, modification, agriculture, mining)

Are there development pressures affecting the property? Or major changes in traditional land use? Or demographic shifts, especially in sites still in the hands of the descendants of their creators, or, for example, traditional ethnic communities.

YES: _____ NO: X

Comment: The National Monument is entirely surrounded by federal lands. There are no major changes in traditional land use and no encroachments by developers or local communities.

(ii) Environmental pressures (e.g., pollution, climat change, desertification)

Are there major sources of environmental deterioration currently affecting the property?

YES: _____ NO: X

Comment: The monument does receive air pollutants from cities to the west, along with El Paso and Juarez, Mexico to the south. However, there is no evidence that these pollutants are affecting the ecosystem. Studies were initiated in 2003 to assess the impacts of atmospheric nitrogen deposition and climate change on Chihuahuan Desert ecosystems. Ozone is not currently a significant concern for vegetation in Chihuahuan Desert park units. At White Sands, an ozone injury risk assessment had a low risk rating for vegetation. The affects of climate change are undetermined.

(iii) Natural disasters and risk preparedness (earthquakes, floods, fires, etc.)

Are natural disasters likely to present a foreseeable threat to the property? If so, are there available background data (e.g., for a property in a seismic zone, give details of past seismic activity, or the precise location of the property in relation to the seismic zone, etc.)

YES: _____ NO: X

Comment: Rarely are there issues with public access. The summer of 2006, was the wettest in 112 years, causing a partial closure of the monument due to standing water on roads and in picnic areas. However, visitors were still accommodated. Natural disasters are not anticipated. The monument is not in an active earthquake zone. Most of New Mexico's historical seismicity has been concentrated over 100 miles to the northwest, in the Rio Grande Valley between Socorro and Albuquerque. About half of the earthquakes of intensity VI or greater (Modified Mercalli intensity) that occurred in the State between 1868 and 1973 were centered in this region. Surprisingly, with the exception of the Socorro Seismic Anomaly, no discernable trend is apparent for the Rio Grande rift, a major flaw in the earth's crust that bisects the state north to south and along which the Rio Grande flows. Fire is not an issue for the park. Seldom are bush fires started by lightning or human carelessness, they are not sustained by the vegetation.

Are there contingency plans for dealing with disasters, whether by physical protection measures or staff training?

YES: X NO: _____

Comment: the monument has written Standards Operation procedures for Weather Emergency and Emergency Medical Services. Monument Law Enforcement Officers are trained emergency medical technicians. The monument also has memorandums of understanding for emergency services with the Otero County Sheriffs Department and Otero County fire department at Alamogordo West.

(iv) Visitor/tourism pressures

If the property is open to visitors, is there an established or estimated "carrying capacity" of the property? Can it absorb or mitigate the current or an increased number of visitors without significant adverse effects?

YES: X NO: _____

Comment: In 1997, visitation reached a high of 643,386 and has since dropped to 441,747 in 2006. For the most part visitation is spread throughout the year with a few exceptional days. The park experiences significant visitation by the local community on holidays like Easter and the day after Thanksgiving. Easter visitation reached 7,231 in 2006. On these exceptional days, the monument has had traffic congestion at the entrance station. The monument has redesigned the entrance station and roadway and will begin construction in 2007 to remedy the occasional traffic congestion.

(v) Other

Are there any other risks or threats that could jeopardize the property's Outstanding Universal Values?

YES: _____ NO: X

Comment: There are no foreseeable risks or threats.

5. PROTECTION AND MANAGEMENT

5.a. Ownership

Provide the name(s) and addresses of all owners:

United States of America, Department of the Interior, National Park Service.
White Sands National Monument is located at 19955 Highway 70 West, Alamogordo,
NM 88310.

If any of these owners are corporations or other nongovernmental entities, identify which are public and which private. Identify any traditional or customary owners.

Public organization owners: _____

Private organization owners: _____

Traditional or customary owners: _____

If there are any other authorities with legal responsibility for managing the property, provide their names and addresses:

None _____

For properties having multiple owners, is there any representative body or agent which speaks for all owners? If so, does that representative body or agent have authority to act on behalf of all the owners? If so, provide the name and address of that representative body or agent:

Are there any restrictions on public access to the property?

Explanation: Public access is not required for inclusion in the World Heritage List. Policies in effect should be explained, however.)

YES: X

NO:

Comment: The monument has public access, a visitor center, concession, hiking trails, picnic areas and restroom facilities. However, the monument is surrounded by Department of Defense land which provides a large measure of protection from trespass. The west and north sides of the monument can be accessed after obtaining an escort or authorized military egress.

5.b. Protective designations

What are the principal existing (and pending) legal measures of protection that apply to the property?

Explanation: List, but do not attach copies of, all relevant known or proposed legal, regulatory, contractual, planning, institutional and/or traditional measures that affect the status of the property: e.g., national park, wildlife refuge, historic monument, zoning, easements, covenants, deed restrictions, State and local historic preservation ordinances and regulations, and the like.

List of measures: United States Federal Law, Executive Orders and National Park Service Policy and Directors Orders

Give the title and date of legal instruments and briefly summarize their main provisions. Provide the year of designation and the legislative act(s) under which the status is provided.

Titles, dates, and brief summaries of legal instruments: including but not limited to

- In 1916, Congress established the National Park Service with the National Park Service Organic act, 16 USC 1.
- General Authorities Act of 1970 Act to clarify the authorities applicable to the National Park Service. Congress further reaffirms, declares, and directs that the promotion and regulation of the various areas of the National Park System
- Section 118 of the 1963 Clean Air Act (42 USC 7401 et. Seq.) requires the National Park Service to meet all federal, state, and local air pollution standards.
- National Park Service policies require protection of water quality consistent with the Clean Water Act of 1977.
- The Endangered Species Act (1973 50 CFR Part 17) requires an examination of impacts on all federally-listed threatened or endangered species.
- National Environmental Policy Act (NEPA 1969 40 CFR Parts 1500 - 1508) requires assessment of cumulative impacts in the decision-making process for federal projects.
- Executive Order 11988 for Floodplain Management
- Executive Order 11990 for Protection of Wetlands
- Executive Order 13112 for Invasive Species Management

- The Management Policies: U.S. Department of the Interior National Park Service 2006 and Directors Orders for detailed written guidance to help managers make day-to-day decisions

Are the protections in perpetuity or are there potential gaps in the protection?

YES: X NO: _____

Comment: Protection is in perpetuity

Are there any traditional ways in which custom safeguards the property?

YES: _____ NO: X

Comment: _____

5.c. Means of implementing protective measures

Will the owner(s) be responsible for ensuring that the nominated property will be protected in perpetuity, whether by traditional and/or statutory agencies? If no, identify who will be responsible.

YES: X NO: _____

Responsible entity other than the owner: _____

What is the adequacy of resources available for this purpose? Please briefly explain your reasoning.

The proposed site is a National Monument within the United States of America, funds for management and protection should be available in perpetuity.

5.d. Existing plans related to municipality and region in which the proposed property is located (e.g., regional or local plan, conservation plan, tourism development plan)

Explanation: List, but do not attach, plans of which you are aware that have been officially adopted or are currently under development by governmental or other agencies that you believe directly influence the way the property is developed, conserved, used or visited. Include the dates and agencies responsible for their preparation and describe their general nature, including whether they have the force of law. It is recognized that this information may be difficult to compile and that it may be difficult to decide what to include, but the information will be very useful in determining how well the property is protected.

property and illustrate the qualities/features that you believe justify the nomination of the property to the World Heritage List. (Ten views or so should be adequate for all but the most complicated properties.)

Please label the images you supply and provide a separate list of them here, including the photographer's name. Please do not include any copyrighted images or other images to which you do not possess the rights or do not have permission.

Images being supplied and names of their authors:

1. Landscape by Diane White
2. Landscape by Diane White
3. Cottonwood Tree Engulfed by Sand by Diane White
4. Sunset in Dunes by John Creager
5. Child on Dune by John Creager
6. Moon Rise Over Dunes by John Creager
7. Storm Over National Monument by John Creager
8. Public Tour of Lake Lucero by John Creager
9. Selenite Crystals on Shore Line by John Creager
10. Public Tour of Gypsum Pedestal by John Creager
11. White Faced Ibis by David Bustos
12. American Avocet by David Bustos
13. Tamarisk Pedestals in the Dunes by David Bustos
14. Over View of White Sand Dunes by David Bustos
15. Bleached Earless Lizard by David Prival

8. CONTACT INFORMATION

8a. Preparer/Responsible Party for Contact:

Name: Diane White

Title: Resource Program Manager

Address: White Sands National Monument, PO Box 1086,

City, State/Territory, Zip Code: Holloman AFB, NM 88330

Telephone: 505-679-2599 x223

Cellular phone: _____

Preferred Days/Hours for Contact: Monday-Friday 7:30 AM - 4:00 PM, Mountain Time

Fax: 505-479-4333

E-mail and/or website: diane_white@nps.gov

8.b. Responsible Official or Local Institution/Agency

If different from the preparer above, provide the same information for the agency, museum, institution, community or manager locally responsible for the management of the property. In the case of public property, identify both the responsible official and the agency. If the normal reporting institution is a national agency, please also provide that contact information.

Name: Cliff Spencer

Title: Superintendent

Address: White Sands National Monument, PO Box 1086

City, State/Territory, Zip Code: Holloman AFB, NM 88330

Telephone: 505-679-2599 x210

Cellular phone: _____

Fax: 505-479-4333

E-mail and/or website: cliff_spencer@nps.gov

9. Signatures of All Owners of Private Properties or Authorizing Officials for Public Properties:

Explanation: No property will be included in the U.S. World Heritage Tentative List without the written concurrence of all its property owners. This is because U.S. law expressly forbids nomination of such sites. In addition, at the time of nomination, property owners must pledge to the legal protection or the development of legal protection of the property in perpetuity.

Signature

Cliff Spencer

Typed or Printed Name

Superintendent

Title

March 8, 2007

Date

(Please attach as many additional signature pages as may be necessary.)

References

1964. *Eucanthus impressus*, new species. In *The Geotrupinae of North and Central America*. Entomology Research Institute, Research Branch, Canada Department of Agriculture, Ottawa, Ontario.
1968. White Sands National Monument. In *Shifting sands: the story of sand dunes*. John Day Company, New York City.
1977. Transactions of the symposium on the biological resources of the Chihuahuan Desert region, United States and Mexico. Sul Ross State University, Alpine, TX, National Park Service, 17-18 October 1974.
- Adamski, D. and E. H. Metzler. 2000. A new species of *Glyphidocera* Walsingham from southwestern Ohio. *Proceedings of the Entomological Society of Washington* 102(2): 301-307.
- Alberico, M. S. 1973. Distribution and ecology of two pocket gopher species in south central New Mexico. Thesis. New Mexico State University, Las Cruces, NM.
- Alberico, M. S. 1978. Species diversity of nocturnal rodents in disturbed desert-grassland habitats. Dissertation. New Mexico State University, Las Cruces, NM.
- Allmendinger, R. J. 1971. Hydrologic Control over the Origin of Gypsum at Lake Lucero, White Sands National Monument, New Mexico. Thesis. New Mexico Institute of Mining and Technology, Socorro, NM.
- Allmendinger, R. J. and F. B. Titus Jr. 1973. Regional Hydrology and Evaporative Discharge as a Present-day Source of Gypsum at White Sands National Monument, New Mexico. New Mexico Bureau of Mines and Mineral Resources, Socorro, NM.
- Amos, W. H. 1959. The life of a sand dune. *Scientific American* 201:91-99.
- Anderson, D. L. 2001. Alien or exotic plant species: White Sands Missile Range, New Mexico.
- Anderson, D. L. and G. Michaud. 2000. List of plant species observed on 5 April 2000 between Mike Site on White Sands Missile Range and Lake Lucero on White Sands National Monument.
- Anderson, R. 1965. Analyses of Mineral Content of Ground Water Samples Taken on the Loop Drive and at Lake Lucero.
- Anderson, R. 1965. Core Samples Taken at Lake Lucero.

Anderson, R. 1966. Core Samples Taken at Lake Lucero and Near WSMR Route No 6.
Antevs, E. 1954. Climate of New Mexico during the last Glacio- Pluvial. *Journal of Geology* 62:182-191.

Atkinson, R. 1977. *White Sands: Wind, Sand and Time*. Southwest Parks and Monuments Association, Globe, AZ.

Author Unknown. 1968. Check list of the plants of White Sands National Monument.

Author Unknown. 1994. A checklist of mammals, reptiles, amphibians and arthropods of White Sands National Monument. Southwest Parks and Monuments Association, Tucson, AZ.

Author Unknown. 1994. A checklist of the plants of White Sands National Monument. Southwest Parks and Monuments Association, Tucson, AZ.

Author Unknown. 1999. Checklist of the plants at White Sands National Monument.

Author Unknown. 2000. Guadalupe Mountains National Park exotic plant list.

Author unknown. 1941. Major Flowering Plants, White Sands National Monument.

Author unknown. 1958. Miscellanea. Western Reserve Academy Natural History Museum Publication 1:17.

Author unknown. 1962. Sand Research Project. National Park Service.

Author unknown. 1964. Untitled: Figures from Tularosa Basin New Mexico Saline Ground-Water Investigation. Map. United States Geological Survey.

Author unknown. 1965. Resource Base, Part of the Master Plan, White Sands National Monument, New Mexico. Map. National Park Service, Western Office, Design and Construction.

Author unknown. 1965. Untitled file folder: Mineralogical Analysis of Soil Samples, White Sands National Monument, NM.

Author unknown. 1979. *Geology of Sand Dunes*.

Author unknown. 1985. *Salt Cedar Removal Action Plan*.

Author unknown. 1985. *White Sands Pupfish*. In *Handbook of Species endangered in New Mexico*. New Mexico Department of Game and Fish, Santa Fe.

Author unknown. 1989. Plants and animals of White Sands: A discussion of dunes ecology with revised checklists. White Sands National Monument, Holloman Air Force Base, NM.

Author unknown. 1991. White Sands National Monument Bird Checklist.

Author unknown. 1991. Wind research with University of Texas, White Sands National Monument.

Author unknown. 1992. Dune Temperature Data Record Sheets.

Author unknown. 1992. Great Sand Dunes National Monument Researchers Symposium 1992.

Author unknown. 1993. A checklist of the birds of White Sands National Monument. Southwest Parks and Monuments Association, Tucson, AZ.

Author unknown. 1993. Qualitative Diatom Analysis of Lost River, White Sands National Monument: Multiple epiphyte mix; Qualitative Diatom Analysis of North Lake Lucero.

Author unknown. 1993. White Sands Pupfish.

Author unknown. 1993. Wildlife Occurring in One or More of the Following Counties; Chaves, Dona Ana, Lincoln, Otero, Sierra, Socorro, NM.

Author unknown. 2003. Geoinicators scoping report for White Sands National Monument: Strategic planning goal Ib4 January 28-30, 2003 Alamogordo, NM.

Author unknown. n.d. Checklist of Reptiles and Amphibians.

Author unknown. n.d. Known Reptiles and Amphibians of White Sands National Monument.

Author unknown. n.d. Known Insects at White Sands National Monument.

Author unknown. n.d. List of Plants in White Sands National Monument-Arranged Alphabetically According to Scientific Names.

Author unknown. n.d. *Peniocereus greggii* at White Sands National Monument.

Author unknown. n.d. Plants of the White Sands.

Author unknown. n.d. Proposal 1: Lake Lucero as a Model for Establishing a Quantitative Classification of Playas.

Author unknown. n.d. Species of the Genus Compositae found at White Sands National Monument.

Author unknown. n.d. The cacti of Carlsbad Caverns, Guadalupe Mountain, Big Bend National Parks and White Sands National Monument.

Author unknown. n.d. White Sands National Monument Bird Checklist.

Author unknown. n.d. White Sands National Monument Mammals List.

Bailey, V. 1932. Mammals of New Mexico. *North American Fauna* 53:1-412.

Balance, W. C. 1967. Ground-water Resources of the Holloman Air Force Base Well-field Area. United States Geological Survey.

Balding, F. R. and G. L. Cunningham. 1974. The influence of soil water potential on the perennial vegetation of a desert arroyo. *The Southwestern Naturalist* 19:241-248.

Ball, G. E. and H. V. Danks. 1993. Systematics and Entomology: Diversity, Distribution, Adaptation, and Application. *Memoirs of the Entomological Society of Canada* 165.

Banghold, R. A. 1941. The physics of blown sand and desert dunes. Chapman and Hall, London.

Barud-Zubillaga, A. 2000. A conceptual model of the hydrology of White Sands National Monument, south-central New Mexico. Thesis. Department of Geological Sciences, University of Texas at El Paso, El Paso, TX.

Bath, G. D. 1977. Aeromagnetic maps with Geological interpretation for the Tularosa Valley, South-Central New Mexico. US Geological Survey.

Bath, G. D., D. L. Healy, and L. S. Karably. 1977. Combined analysis of gravity and magnetic anomalies at Tularosa Valley, New Mexico. *Abstract with Programs Geological Society of America* 9:3-4.

Bedinger, M. S., W. H. Langer, and J. E. Reed. 1986. Synthesis of hydraulic properties of rocks with reference to the Basin and Range Province, southwestern United States. In *Selected Papers in the Hydrologic Sciences*. United States Geological Survey, Denver.

Beehner, T. S. 1987. Earthquake-potential at White Sands Missile Range, New Mexico. Engineering geology and industrial development Annual Meeting Association of Engineering Geologists. Atlanta, GA.

Belknap, W. 1957. New Mexico's Great White Sands. *National Geographic* 90:113-137.

Bell, E. E., and L. Eisner. 1956. Infrared Radiation from the White Sands at White Sands National Monument, New Mexico. *Journal of the Optical Society of America* 46:303-304.

Bennett, J. P. and C. M. Wetmore. 2005. Lichens of the U.S. National Parks. *The Biologist* 108:544-553.

Benson, S. B. 1933. Concealing coloration among some desert rodents of the southwestern United States. University of California Press, Berkeley.

Blair, W. F. 1941. Annotated List of Mammals of the Tularosa Basin, New Mexico. *American Midland Naturalist* 26:218-229.

Blair, W. F. 1941. Color variation in the spotted ground squirrels of the Tularosa Basin, New Mexico. *Contributions from the Laboratory of Vertebrate Genet, University of Michigan, WI.*

Blair, W. F. 1943. Ecological distribution of mammals in the Tularosa Basin, New Mexico. *Contributions from the Laboratory of Vertebrate Biology, University of Michigan, WI.*

Blair, W. F. 1947. Estimated frequencies of the buff and gray genes in adjacent populations of deer mice living on soils of different colors. University of Michigan, Ann Arbor. *Contributions from the Laboratory of Vertebrate Biology* 36.

Blair, W. F. 1947. Variation in shade of pelage of local populations of the cactus mouse in the Tularosa Basin, and adjacent area of southern New Mexico. *Contributions from the Laboratory of Vertebrate Biology* 37:1-7.

Borell, A. E. 1935. List of birds observed at "Pool of Siloam" Otero County, New Mexico March 19 to 26, 1935. White Sands National Monument, Holloman AFB, NM.

Borell, A. E. 1936. The Western Palm Warbler in New Mexico. *Condor* XXXVIII:177.

Borell, A. E. 1937. The Marbled Godwit and Sanderling in New Mexico. *Condor* XXXIX:132.

Borell, A. E. 1938. Birds of White Sands National Monument, New Mexico.

Borell, A. S. 1934. Untitled: White Sands bird observations. National Park Service, Southwest Monuments.

Botkin, C. W. 1933. The White Sands National Monument. *Pan-American Geologist* 60:304-305.

Botkin, C. W. n.d. Origin of the White Sands.

- Bowers, J. E. 1982. The Plant Ecology of Inland Dunes in Western North America. *Journal of Arid Environment* 5:199-220.
- Bowers, J. E. 1986. *Seasons of the Wind: A Naturalists Look at the Plant Life of the Southwestern Sand Dunes*. Northland Press, Flagstaff, AZ.
- Brady, F. W. 1905. The White Sands of New Mexico. *Mines and Minerals* 25:529-530.
- Brown, J. H. and G. A. Lieberman. 1973. Resource utilization and coexistence of seed-eating desert rodents in sand dune habitats. *Ecology* 54:788-797.
- Buffington, L. C. and Herbal. 1965. Vegetation changes on a semi-desert grassland. *Ecological Monographs* 35:139-164.
- Bugbee, R. E. 1942. Notes on animal occurrence and activity in the White Sands National Monument, New Mexico. *Transactions Kansas Academy of Science* 45:315-321.
- Bulloch, H. E. Jr. and R. E. Neher. 1980. Soil survey of Dona Ana County area, New Mexico. US Department of Agriculture.
- Bundy, R. E. 1955. Color Variation in Two Species of Lizards. Thesis. University of Wisconsin, Madison, WI.
- Burkett, D. W. 2003. Amphibians and reptiles checklist. Environmental Stewardship Division Directorate of Environment and Safety, White Sands Missile Range, NM.
- Burkett, D. and L. Kamees. 1996. Mammals of White Sands Missile Range.
- Burkett, D. and Palmer. 2000. Amphibians and reptiles of White Sands Missile Range, New Mexico.
- Cameron, R. E. and G. B. Blank. 1966. Desert Algae: soil crusts and diaphanous substrata as algal habitats. California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA.
- Campbell, R. S. and I. F. Campbell. 1938. Vegetation on Gypsum Soils of the Jornada Plain, New Mexico. *Ecology* 19:572-577.
- Carter, J. 2002. White Sands herbarium specimen inventory - August 20, 2002.
- Chandler, D. S. 1975. A revision of the *Tanarthrus* LeConte with a presentation of its mid-cenozoic speciation. *Transactions of the American Entomological Society* 101(2):310-354.
- Charles, T. 1932. *Sands that Grow*. New Mexico.

Chavdarian, G. V. 2005. Cracks and Razorbacks: Pieces of Mars at White Sands National Monument, New Mexico. Thesis. University of California, Davis.

Chavdarian, G. V. and D. Y. Sumner. 2006. Cracks and fins in sulfate sand: Evidence for recent mineral-atmospheric water cycling in Meridian Planum outcrops? *Geology*. 34:229-232.

Chronic, H. 1986. White Sands National Monument. In *Pages of Stone; Geology of Western National Parks and Monuments 3: The Desert Southwest*. The Mountaineers, Seattle.

Chronic, H. 1987. *Roadside Geology of New Mexico*. Mountain Press Publishing Company, Missoula, MT.

Chun, D. T. 1972. Measured physiological limitations of microorganisms isolated from Lake Lucero and gypsum crystal. Thesis. New Mexico State University, NM.

Cinnamon, S. K. 1979. *Vulpes macrotis* at White Sands. In *White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report*. University of Texas at El Paso, Laboratory for Environmental Biology, El Paso, TX.

Cinnamon, S. 1976. *Untitled: Report on Roadrunner observations*.

Cipar, J. J. 1987. Crustal structure of the Tularosa Valley, southern Rio Grande Rift, New Mexico. *Eos, Transactions, American Geophysical Union*. San Francisco, CA.

Clary, M. L., D. M. Bell, C. W. Edwards, T. W. Jolley, O. Knayazhnitsky, N. Lewis-Oritt, S. J. Mantooh, L. L. Peppers, I. Tiemann-Boege, F. D. Yancey II and others. 1999. Checklist of mammals from twelve habitat types at Fort Bliss Military Base, 1997-1998. Natural Science Research Lab, The Museum, Texas Tech University, Lubbock, TX.

Cockerell, T. D. A. and F. Gracia. 1898. Preliminary Note on the Growth of Plants in Gypsum. *Science* 8:119-121.

Cole, R. A., D. L. Weigmann and M. C. Hayes. 1984. Limnology of a shallow Brackish, Hypereutrophic Reservoir in Southern New Mexico. New Mexico State University, Las Cruces, NM.

Cole, R. S., D. L. Weigmann and M. Hayes. 1981. A limnological study of Lake Holloman with management recommendations for multiple uses. US Bureau of Land Management, Santa Fe. Final Recommendation Report Contract NM-910-CTO-7.

Conrod, B. 2004. Mammal list, White Sands National Monument.

- Conrod, B. 2005. Summary: Ground water monitoring data, White Sands National Monument.
- Conrod, B. 2005. Summary: Threatened and endangered species.
- Controls for Environmental Pollution, Inc. 1985. Reports on Analysis of Water quality from Lost River Area June 1985.
- Cooper, J. B. 1958. Ground-water in the vicinity of Carrizozo, Lincoln County, New Mexico. United States Geological Survey.
- Cooper, J. B. 1958. Ground-water resources of the northern Tularosa Basin near Carrizozo, Lincoln County, New Mexico.
- Coulson, D. L. 1997. White Sands National Monument's Tamarix control 1997.
- Coville, F. V. and D. T. Macdougall. 1903. Desert Botanical Laboratory of the Carnegie Institution.
- Cox, A., F. Deckert, M. G. Scott, J. Yarbrough, E. Richard and J. Mack. 2002. Amendment to the full study plan for vertebrate and vascular plant inventory of the Chihuahuan Desert Network.
- Crabaugh, M. C. 1989. White Sands National Monument and the Coppice Dunes of Southeast New Mexico. In The University of Texas at Austin, Department of Geography. Geomorphology of the Southwest. The University of Texas at Austin, Department of Geography, Austin, TX.
- Crawford, W. P. 1973. Check list of plants known to occur in White Sands National Monument.
- Cutak, L. 1939. Plant life in the shimmering White Sands. *Desert Plant Life*. 11:145-147.
- Darton, N. H. 1930. White Sands. United States Geological Survey. Bulletin 794 (59).
- Davis, D. R., J. S. Hopkins, and K. Casula. 1996. Lake water quality assessment surveys: Playa lakes 1993. New Mexico Environment Department, Santa Fe.
- Davis, D. 1993. Qualitative Diatom Analysis of Lost River, White Sands Natl. Monument.
- Davis, G. A., Y. Piceno, and M. Wimpee. 1999. University of Texas at El Paso: Phospholipid fatty acid analysis.

Davis, L. V., and F. E. Busch. 1965. Summary of Hydrologic Investigations by the US Geological Survey at White Sands Missile Range, New Mexico. United States Geological Survey. Open File Report NM115.

Degenhardt, W., C. W. Painter, and A. H. Price. 1996. Amphibians and reptiles of New Mexico. University of New Mexico Press, Albuquerque.

Derr, P. S. 1981. Soil survey of Otero area, New Mexico, Parts of Otero, Eddy, and Chaves Counties. US Department of Agriculture.

Dice, L. R. 1929. Descriptions of Two New Pocket Mice and a New Woodrat from New Mexico. University of Michigan, Ann Arbor. Occasional Papers of the Museum of Zoology 203.

Dice, L. R. 1930. Mammal distribution in the Alamogordo region, New Mexico. University of Michigan, Ann Arbor. Occasional Papers of the Museum of Zoology, No. 213.

Dick-Peddie, W. A. 1993. New Mexico Vegetation: Past, Present, and Future. University of New Mexico Press, Albuquerque, NM.

Dick-Peddie, W. A., and W. H. Moir. 1970. Vegetation of the Organ Mountains. Colorado State University, Fort Collins, CO. Range Sciences Department Report 4.

Dick-Peddie, W. A., D. I. Axelrod, F. E. Kottlowski, J. W. Hawley, A. L. Lamarre, W. E. King, J. S. Mclean, E. R. Decker, C. E. Chapin, W. E. Seager and others. 1955. INCLUDES: Vegetation of southern NM; Tertiary floras from the Rio Grande Rift; Stratigraphy of the San Andres Mountains in south-central NM; Quaternary history of Dona Ana County region, south-central NM. In The New Mexico Geological Society Guidebook of Southeastern New Mexico: sixth field conference. New Mexico Geological Society.

Dingwall, P., T. Weighell, and T. Badben. 2005. Geological World Heritage: A Global Framework.

Dittmer, H. J. 1959. A study of the root systems of certain sand dune plants in New Mexico. Ecology 40:265-273.

Dixon, J. R. 1967. Aspects of the Biology of the Lizards of the White Sands, New Mexico. Contributors in Science, Los Angeles County Museum.

Dixon, J. R. and P. A. Medica. 1966. Summer Food of Four Species of Lizards from the Vicinity of White Sands, New Mexico. Contributions in Science.

Dodge, N. N. 1971. The natural history story of White Sands National Monument. Southwest Parks and Monuments Association, Globe, AZ.

- Dodson, C. 1990. Herbaria of New Mexico. *Madrono* 37:311-313.
- Douglass, J. R., E. D. Mckee, and S. Rittenhouse. 1963. Untitled file folder: Sand Dune Movement Study.
- Duschatko, R. W. 1953. Fracture Studies of the Lucero Uplift, New Mexico. US Atomic Energy Comm. RME-3072.
- Echelle, A. F., and D. R. Edds. 1987. Population structure of four pupfish species from the Chihuahuan Desert Region of New Mexico and Texas: Allozymic variation. *Copeia* 668- 681.
- Echlin, R. D. 1977. Plant Community Structure in Northeastern White Sands National Monument, New Mexico. Thesis. University of Texas at El Paso, El Paso, TX.
- Emerson, F. W. 1935. An ecological reconnaissance in the White Sands, New Mexico. *Ecology* 16:226-233.
- Emerson, F. W. n.d. Checklist of the Seed plants of the White Sands.
- Energy and Resource Consultants, Inc. 1988. Air quality in the National Parks: A summary of findings from the National Park Service Air Quality Research and Monitoring Program. National Park Service, Air Quality Division.
- Ero, K. M. 1978. Epidemiology, distribution and isolation of pathogenic fungi from northeastern White Sands National Monument, New Mexico. Thesis. University of Texas, El Paso, El Paso, TX.
- Esterak, J. A. 2000. Relationships between *Yucca elata* and gypsum dunes at White Sands National Monument. Thesis. Department of Biological Sciences, University of Texas at El Paso, El Paso.
- Farhadnejad, D. O. 1975. The Seed Germination Ecology of Three Species of *Gaillardia* which occur in the Gypsumlands Areas of Eastern New Mexico. Thesis. Eastern New Mexico University.
- Findley, J. S. 1987. The natural history of New Mexico mammals. University of New Mexico Press, Albuquerque, NM.
- Fischer, H. 1967. The White Sands, die Gipswüste in New Mexico, USA. *Naturwissenschaftliche Rundschau* 20:426-432.
- Fletcher, J. 1981. The selenite crystal beds at Lake Lucero, White Sands National Monument. *Lapidary Journal* 35:470-474.

Flower, R. H., M. L. Thompson, F. E. Kottlowski, H. P. Bushnell, V. C. Kelley, C. S. Conover, E. H. Herrick, J. W. Wood, J. E. Weir Jr. and J. P. Fitzsimmons. 1955. Includes: Nomenclature Chart New Mexico Geological Society Precambrian rocks of south-central New Mexico. In *The New Mexico Geological Society Guidebook of Southeastern New Mexico: sixth field conference*.

Frank, A., and G. Kocurek. 1990. Airflow up sand dunes: Limitations of current understanding. Department of Geological Sciences, University of Texas, Austin, TX.

Frank, A., and G. Kocurek. 1993. Effects of Atmospheric Conditions on Wind Profiles and Eolian Sand Transport with an Example from White Sands National Monument. US Department of Agriculture, Washington, DC. Circular 61.

Frank, A., and G. Kocurek. 1993. Near surface atmospheric convection and its effects on wind profiles and eolian sand transport; with an example at White Sands National Monument, New Mexico. Abstracts with Programs Geological Society of America. Boston, MA.

Frank, A., and G. Kocurek. 1993. Wind profiles on the stoss slope of sand dunes; implications for eolian sand transport. Abstracts with Programs Geological Society of America 25:39.

Frank, A., and G. Kocurek. 1994. Effects of atmospheric conditions on wind profiles and aeolian sand transport with an example from White Sands National Monument. *Earth Surface Processes and Landforms* 19:735-745.

Freeman, C. E., R. S. Tiffany, and W. H. Reid. 1977. Germination responses of *Agave lechuhuilla*, *A. Parryi* and *Fouquieria splendens*. *Southwestern Naturalist* 22:195-204.

Frenzel, P. F., and C. A. Kaehler. 1990. Geohydrology and simulation of ground-water flow in the Mesilla Basin, Dona Ana County, New Mexico and El Paso County, Texas. United States Geological Survey, Albuquerque, NM. U.S. Geological Survey Open-File Report 88-305.

Frey, J. K. 2004. Taxonomy and distribution of the mammals of New Mexico: An annotated checklist. Museum of Texas Tech University.

Fryberger, S. G., C. J. Schenk, and L. F. Krystinik. 1988. Stokes surfaces and the effects of near-surface groundwater-table on aeolian deposition. *Sedimentology* 35:21-41.

Fryberger, S. 1997. Geological overview of White Sands National Monument. Southwest Parks and Monuments Association, Tucson.

Fuchs, B. 1994. White Sands National Monument and the. In Author unknown. Nature Conservancy, New Mexico Chapter Newsletter. Santa Fe.

Fuzessery, Z. M., and J. C. Hall. 1999. Sound duration selectivity in the pallid bat inferior colliculus. *Hearing Research* 137:137-154.

Gardner, D. 1988. White Sands Pupfish Seldom Visited. Unknown source.

Garza, S., and J. S. Mclean. 1977. Freshwater Resources in the Southeastern Part of the Tularosa Basin. New Mexico State Engineer.

George, M. 2004. Visibility at White Sands National Monument.

Goldman, E. A. 1933. New mammals from Arizona, New Mexico and Colorado. *Journal of the Washington Academy of Sciences* 23:463-473.

Goodding, L. N. 1938. Note on native and exotic plants in region eight, with specific reference to their value in the soil conservation program. USDA, Soil Conservation Service, Region Eight, Albuquerque, NM.

Gould, C. N. 1937. Geological Report on White Sands National Monument.

Gould, C. N. 1937. Geological Reports.

Gould, C. N. 1937. Second Geological Report on White Sands National Monument.

Gould, C. N. 1938. Fourth Geological Report White Sands National Monument, Report 184.

Gould, C. N. 1938. Third Geological Report on White Sands National Monument.

Gross, F. A., and W. A. Dick-Peddie. 1979. A map of primeval vegetation in New Mexico. *The Southwestern Naturalist* 24:115-122.

Hafner, D. J., and K. N. Geluso. 1983. Systematic Relationships and Historical Zoo Geography of the Desert Pocket Gopher *Geomys arenarius* Museum of Southwestern Biology, Department of Biology, Albuquerque, NM. *Journal of Mammalogy* 64:405-413.

Hagar, S. B. 1998. Thermoregulatory and reproductive behavior of the *Holbrookia maculata* lesser earless lizard at White Sands National Monumeht, New Mexico. Thesis. Biology Department, New Mexico State University, Las Cruces, NM.

Hagar, S. B. 2001. Microhabitat use and activity patterns of *Holbrookia maculata* and *Sceloporus undulatus* at White Sands National Monument, New Mexico. *Journal of Herpetology* 35:326-339.

Hager, S. B. 2001. The role of nuptial coloration in female *Holbrookia maculata*: Evidence for a dual signaling system. *Journal of Herpetology* 35:624-632.

- Hamilton, N. 1978. Charting a sea of sand: UT El Paso at White Sands National Monument. NOVA 14:1-4.
- Harper, M. 1982. Distribution of the Chihuahuan desert herpetofauna and its relation to the climate. Thesis. University of Texas at El Paso, El Paso, TX.
- Harris, A. 2002. White Sands National Monument-Mammals.
- Harris, D. V., and E. P. Kiver. 1985. Basin and Range Province; White Sands National Monument. In *The Geologic Story of the National Parks and Monuments*. John Wiley and Sons, New York City.
- Harriton, E. R. 1940. Valley of the Sands. *New Mexico Magazine* XVIII 9-11.
- Hawley, J. W., and F. E. Kottlowski. 1969. Quaternary geology of the south-central New Mexico border region. In *Border Stratigraphy Symposium*. New Mexico Bureau of Mines and Mineral Resources.
- Heil, K. D., and S. Brack. 1984. Survey and monitoring of endangered cactus species at Big Bend National Park, Texas, Carlsbad Caverns, New Mexico, Guadalupe Mountains National Park, Texas, and White Sands National Monument, New Mexico.
- Heil, K. D., and S. Brack. 1984. Technical review draft: The rare and sensitive cactus of White Sands National Monument.
- Heil, K. D., and S. Brack. 1986. *The cacti of White Sands National Monument*. Cactus and Succulent Society of America, Santa Barbara, CA.
- Helfert, S. C. 1978. Reproductive Ecology of Three Lizard Species at White Sands National Monument, New Mexico. Thesis. University of Texas, El Paso, TX.
- Helfert, S. C., and R. M. Helfert. 1977. White Sands National Monument studies: Preliminary report on the fauna of Garton Pond and the adjacent artesian well. University of Texas, El Paso. Laboratory for Environmental Biology, Research Report Number 7.
- Hendrickson, P. 1976. Lake Lucero. Southwest Parks and Monuments Association, Globe, AZ.
- Henry, A., and K. Cathey. 1992. Final report: Habitat assessment for Aplomado Falcons on White Sands Missile Range June - November 1992.
- Herbal, C. H., and R. D. Pieper. 1970. Comprehensive Site Description. US International Biological Program Grasslands Biome. Jornada Technical Report 43.
- Herrick, C. L. 1900. The Geology of the White Sands of New Mexico. *Journal of Geology* 8:112-128.

Herrick, C. L. 1904. Lake Otero, an Ancient Salt Lake in Southeastern New Mexico. *The American Geologist* 34:174-189.

Herrick, C. L. 1904. The White Sands. *US Geological Survey Bulletin* 223:98-99.

Herrick, C. L. n.d. Lake Otero, an ancient salt lake in southeastern New Mexico. *American Geologist* 34:174-189.

Herrick, E. H. and L. V. Davis. 1965. Availability of ground water in the Tularosa Basin and adjoining areas, New Mexico and Texas. *US Geological Survey, Washington, DC.*

Herrick, H. N. 1904. Gypsum deposits in New Mexico. *Bulletin US Geological Survey, Bulletin* 223:89-99.

Hogg, D. L. 1979. Plant Phenology in Interdunal Communities at White Sands National Monument, New Mexico. Thesis. University of Texas at El Paso, El Paso, TX.

Hogg, D. L., and W. H. Reid. 1977. White Sands National Monument Studies: Germination Tests Using the Seed of *Yucca elata* Englm. Laboratory for Environmental Biology, University of Texas El Paso, El Paso, TX. Research Report Number 1.

Hogg, D. L., and W. H. Reid. 1979. Phenology and environment in two interdunal communities at White Sands National Monument. *Journal of the Colorado-Wyoming Academy of Sciences* 11:34.

Hoidale, M. M. 1964. Atmospheric structure White Sands Missile Range, New Mexico: Part 2; Temperature, relative humidity, dew point, station pressure, density, clouds hydrometeors, and lithometeors. Meteorological Support Division White Sands Missile Range, New Mexico, ERDA-106, DA Task 1-G-6-50212-A-127-02.

Hölldobler, B., and E. O. Wilson. 1990. *The Ants*. Harvard University Press, Cambridge, MA.

Hood, J. W. 1959. Ground Water in the Tularosa Basin, New Mexico. In *Roswell Geological Society Guidebook of the Sacramento Mountains*. Roswell Geological Society.

Hood, J. W. 1968. Ground water investigations at White Sands Missile Range, New Mexico. *United States Geological Survey*.

Houghton, F. E. 1976. *Climate of White Sands*. Soil Conservation Service, Washington, DC.

Houghton, F. E. 1976. Soil survey of White Sands Missile Range, New Mexico. *US Department of Agriculture, Soil Conservation Service, Washington, DC.*

Houk, R., and M. Collier. 1994. White Sands National Monument. Southwest Parks and Monuments Association, Tucson, AZ

Howden, H. F. 1963. Speculations on some beetles, barriers, and climates during the Pleistocene and Pre-Pleistocene periods in some non-glaciated portions of North America. *Systematic Zoology* 12:178-201.

Hubbard, J. P. 1970. Checklist of the Birds of New Mexico. New Mexico Ornithological Society, Cedar Crest, NM.

Hubbard, J. P., and C. L. Hubbard. 1979. Birds of New Mexico's National Park lands. Tecolote Press, Inc, Glenwood, NM.

Huff, G. F. 2005. Simulation of ground-water flow in the basin-fill aquifer of the Tularosa Basin, South-central New Mexico, predevelopment through 2040. US Geological Survey, Denver, CO. Scientific Investigations Report 2004-5197.

Jackson, E. 1959. How does life endure on the White Sands? *Desert Magazine* 22:13-15.

Jester, D. B., and R. R. Suminski. 1982. Age and Growth, Fecundity, Abundance, and Biomass Production of the White Sands Pupfish, *Cyprinodon tularosa* in a Desert Pond. *Southwestern Naturalist* 27:43-54.

Jicha, H. L. Jr. 1954. The White Sands-a short review. New Mexico Geological Society Guidebook.

Johnson, E. D. 1903. The White Sands of New Mexico. *Out West*. 19:385-387.

Johnson, J. D. 2002. Herpetofauna of White Sands National Monument: Review of Species list.

Jones, B. R. 1959. A sedimentary study of dune sands, Lamb and Bailey counties, Texas and White Sands National Monument. Thesis. Texas Tech University, TX.

Jones, F. A. 1915. The Mineral Resources of New Mexico. New Mexico School of Mines.

Jones, L. P. and J. Riley. 1979. The Microbiology of the White Sands National Monument. In White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report. Laboratory for Environmental Biology, El Paso, TX.

Kamra, A. K. 1971. Dust Storm Electrification. Atmospheric Sciences Research Center, Albany, NY. Grant GA-18667.

- Kain S.M., and E. B. Rosenblum. 2004 Evolution in action: white animals at White Sands. White Sands National Monument, NM.
- Kelly, T. E. 1973. Summary of Ground-Water Data, Post Headquarters and Adjacent Areas, White Sands Missile Range. United States Geological Survey.
- Kidron, G. J., and H. C. Monger. 1998. Microbiotic crusts at the White Sands and other locations within the Northern Chihuahuan Desert.
- Kim, H. 1988. The impact of pocket gophers on a grassland in southern New Mexico. Thesis. University of Texas at El Paso, El Paso, TX.
- Kingsley, M. E. 1978. Epidemeology, distribution, and isolation of pathogenic fungi from northeastern White Sands National Monument, New Mexico. Thesis. University of Texas at El Paso, El Paso, TX.
- Kirchoff, S. 1986. Crustal structure beneath the Tularosa Basin in the White Sands Missile Range, New Mexico. Thesis. Boston University, MA.
- Knapp, J. 1992. Islands in the dunes: An investigation into Pocket Gopher habitat within White Sands National Monument, Otero County, New Mexico. In Ecological research at White Sands National Monument during 1992. University of Texas, El Paso, TX.
- Kocurek, G. A., A. Frank, M. Cradbaugh, and K. Havholm. 1995. Eoloian Dune Systems. White Sands National Monument.
- Kocurek, G., M. Carr, R. Ewing, K. G. Havholm, Y. C. Nagar, and A. K. Singhvi. 2007. White Sands Dune Field, New Mexico: age, dune dynamics and recent accumulations. *Sedimentary Geology* 197:313-331.
- Kottlowski, F. E. 1958. Lake Otero-Second Phase in Formation of New Mexico's Gypsum Dunes. *Bulletin of the Geological Society of America* 62:1732-1735.
- Kottlowski, F. E. 1963. Paleozoic and Mesozoic strata of southwestern and south-central New Mexico. New Mexico Bureau of Mines and Mineral Resources, Socorro, NM.
- Kottlowski, F. E., R. H. Flower, M. L. Thompson, and R. W. Foster. 1956. Stratigraphic Studies of the San Andres Mountains, New Mexico. State Bureau of Mines and Mineral Resources and the New Mexico Institute of Mining & Technology, Socorro, NM. Memoir 1.
- Krieger, R. A., J. L. Hatchett, and J. L. Poole. 1957. Preliminary survey of the saline-water resources of the United States. United States Geological Survey.

Kunkel, K. E. 1984. Temperature and Precipitation Summaries for Selected New Mexico Locations. New Mexico Department of Agriculture, Office of State Climatologist, Las Cruces, NM.

Kyle, J. 1992. Study of the Pocket Gopher habitat at White Sands National Monument, New Mexico. In Ecological Research at White Sands National Monument During 1992. University of Texas, El Paso, TX.

La Tierra Environmental Consulting, L.L.C. 2006. Seasonal Inventory of Birds in Riparian Habitats at Four Chihuahuan Desert Network Parks, National Park Service: Annual Report.

Laick, M. M. 2001. Dune front movement trends at White Sands, New Mexico. Thesis. New Mexico State University, Las Cruces, NM.

Landry, B., and E. H. Metzler. 2002. A new species of *Neodactria* Landry from the middle United States. *Faberies* 27(1): 47-57.

Laudon, L. R., and A. L. Bowsher. 1941. Mississippian Formations of Sacramento Mountains, New Mexico. *Bulletin of the American Association of Petroleum Geologists* 25:2107-2160.

Laudon, L. R., and A. L. Bowsher. 1949. Mississippian formations of Southwestern New Mexico. *Bulletin of the Geological Society of America* 60:1-87.

Lemone, D. V. 1987. White Sands National Monument, New Mexico. In *The Decade of North American Geology Project series*. Geological Society of America, Boulder, CO.

Lemone, D. V. n.d. White Sands National Monument. Department of Geological Sciences, University of Texas at El Paso, TX.

Lewis, T. H. 1949. Dark coloration in the reptiles of the Tularosa Malpais, New Mexico. *Copeia* 1949:181-184.

Lewis, T. H. 1950. The herpetofauna of the Tularosa Basin and Organ Mountains of New Mexico, with notes on some ecological features of the Chihuahuan Desert. *Herpetologica* 6:1-10.

Lewis, T. H. 1981. A Mogollon Description of *Cyprinodon*. *The Southwestern Naturalist* 26:71-72.

Lindberg, J. D., and M. S. Smith. 1973. Reflectance spectra of gypsum sand from the White Sands National Monument and basalt from a nearby lava flow. *American Mineralogist* 58:1062-1064.

Lindberg, J. D., and R. E. Douglass. 1976. The giant orange gypsum crystals in the White Sands National Monument. *Lapidary Journal* 30:924-925.

Logan, K. A., L. L. Sweanor, J. F. Smith, B. R. Spreadbury, and M. G. Hornocker. 1990. Mountain Lion Research: Ecology of an Unexploited Mountain Lion Population in a Desert Environment. New Mexico Dept of Game and Fish.

Lohuis, T. D. and Z. M. Fuzessery. 2000. Neuronal sensitivity to interaural time differences in the sound envelope in the auditory cortex of the pallid bat. *Hearing Research* 143:43-57.

Loomis, W. E. 1944. Effect of Heavy Applications of Gypsum on Plant Growth. *Plant Physiology* 19:706-708.

Lowe, C. H., and K. S. Norris. 1936. A Subspecies of the Lizard *Sceloporus undulatus* From the White Sands of New Mexico. *Herpetologica* 12:125-126.

Lozano, R. 1979. Distribution and ecology of *Coryphantha vivipara*. In White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report. Laboratory for Environmental Biology, El Paso, TX.

Lozano, R. 1979. The distribution and ecology of two *Echinocereus triglochidiatus* populations in White Sands National Monument, New Mexico. Thesis. University of Texas at El Paso, El Paso, TX.

Lozano, R., and W. H. Reid. 1979. Aspects of the ecology of cacti at White Sands National Monument. *Journal of Colorado-Wyoming Academic Science* 11:35.

Lozano, R., and W. H. Reid. 1980. Life history of *Echinocereus triglochidiatus* at White Sands National Monument. *Journal of the Arizona-Nevada Academy of Science* 15:13.

Lozano, R., and W. H. Reid. 1980. On-going study of *Echinocereus triglochidiatus*. In White Sands National Monument natural resources and ecosystem analysis, Volume 1, report of studies. University of Texas at El Paso Laboratory for Environmental Biology.

Lozano, R., and W. H. Reid. 1982. Claret Cup Cactus at White Sands National Monument. *Cactus and Succulent Journal* 54:196-201.

Lozinsky, R.P., and Bauer, R.P.,1991, Structure and Basin-Fill units of the Tularosa Basin, in Barker, J.P., Kues, B.S., Austin, G.S., and Lucas, S.G. editors., New Mexico Geological Society Forty-second Annual Field Conference.

Lucht, D. D. 1964. Biological Evaluation Buck Moth Infestation White Sands National Monument.

- Lueth, V. W., K. A. Giles, S. G. Lucas, B. S. Kues, R. Myers, and D. S. Ulmer-Scholle. 2002. *Geology of White Sands*. New Mexico Geological Society.
- MacKay, W. P., and E. E. Mackay. 1994. *Lasius Xerophilus*, A new species from White Sands National Monument, south central New Mexico. *Psyche* 101:37-43.
- Macfarland, C. 1969. *Habitat partitioning among the three species of lizards from White Sands National Monument, New Mexico*. Thesis. University of Wisconsin, Madison, WI.
- Mackay, W. P. 1992. *Ecological research at White Sands National Monument during 1992*. University of Texas, El Paso, TX.
- Mackay, W. P. n.d. *The thermal ecology of a desert community of darkling beetles at White Sands National Monument, NM*.
- Maker, H. J., P. S. Dear, and J. U. Anderson. 1972. *Soil Association and Land Classification for Irrigation, Otero County*. New Mexico State University, Las Cruces, NM. Agricultural Experiment Station Research Report 238.
- Mangimelli, J. 2002. *Checklist of birds of White Sands National Monument*.
- Mapes, G., and J. T. Schabillion. 1979. *Millaya Gen N, an upper Paleozoic genus of Marattialean Synangia*. *American Journal of Botany* 66:1164-1172.
- Martinez, J. D. 1970. *The relationship between optical orientation and shape anisotropy in detrital gypsum grains*. In *Symposium on Salt* 1:331-338.
- May, R. M. 1988. *How many species are there on earth?* *Science* 241: 1441-1449.
- Mayberry, L. F., and J. R. Bristol. 1979. *Parasite Survey from White Sands National Monument*. In *White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report*. Laboratory for Environmental Biology, University of Texas, El Paso, TX.
- Mayberry, L. F., J. R. Bristol, and D. W. Duszynski. 1980. *Isospora Californica in Peromyscus Maniculatus from White Sands National Monument, New Mexico*. *The Southwestern Naturalist* 25:125-126.
- Mayberry, L. F., J. R. Bristol, D. W. Duszynski, and W. H. Reid. 1980. *Eimeria macrotis from Vulpes macrotis neomexicanus Merriam, 1902*. *Zeitschrift fur Parasitenkunde Parasitology Research* 61:197-200.
- McKee, E. D., and J. R. Douglass. 1971. *Growth and movement of dunes at White Sands National Monument, New Mexico*. In *Geological Survey Research, United States Geological Survey*.

- McKee, R. 1976. Known reptiles and amphibians of White Sands National Monument.
- Mccullough, D. G. 1977. Meteorological Data Report: Moonrise, Moonset & Moon Phases 1978 White Sands Missile Range. Atmospheric Sciences Laboratory, White Sands Missile Range, NM.
- Mcdougall, W. B. 1938. Activities of Wildlife Technician, August 1 to August 31, 1938.
- Mcdougall, W. B. 1939. Special Report: Rate of Sand Movement at White Sands National Monument.
- Mcdougall, W. B. 1939. Vegetation of the White Sands. In National Park Service, Southwest Monuments.
- Mcdougall, W. B. 1939. Wildlife Projects at White Sands. In National Park Service, Southwest Monuments.
- Mcdougall, W. B. 1940. Plant of the White Sands, special report.
- Mcdougall, W. B. 1942. Check List of Plants Known to Occur in White Sands National Monument.
- Mckee, E. D. 1966. Dunes Structures. *Sedimentology* 7:1-69.
- Mckee, E. D. 1966. Structures of dunes at White Sands National Monument, New Mexico. *Sedimentology* 7:3-69.
- Mckee, E. D. 1979. White Sands National Monument. In *A Study of Global Sand Seas*. United States Geological Survey, Washington, DC.
- Mckee, E. D., and R. J. Moiola. n.d. Geometry and growth of the White Sands dune field, New Mexico. *US Geological Survey Journal of Research* 3:59-66.
- Mckee, E. D., J. R. Douglass, and S. Rittenhouse. 1971. Deformation of Lee-Side Laminae in Eolian Dunes. *Geological Society of America Bulletin* 82:359-378.
- McKee, R. 1973. The Herpetofauna of the Tularosa Basin.
- Mckinnerney, M. R. 1977. Carrion communities in the Northern Chihuahuan Desert. Thesis. University of Texas at El Paso, El Paso, TX.
- Mckinnerney, M. R. 1978. Carrion communities in the northern Chihuahuan Desert. *The Southwestern Naturalist* 23:563-576.

- McLean, J. S. 1970. Saline Ground-Water Resources of the Tularosa Basin, New Mexico. US Department of the Interior, Office of Saline Water Research and Development.
- Medica, P. A. 1967. Food Habits, Habitat Preference, Reproduction, and Diurnal Activity in Four Sympatric species of Whiptail Lizards in South Central New Mexico. *Bulletin of the Southern California Academy of Sciences* 66:251-276.
- Meeks, T. O. 1950. The Occurrence of Ground Water in the Alamogordo-Tularosa Area of the Otero Soil Conservation District, New Mexico. Soil Conservation Service.
- Meinzer, O. E. and R. F. Hare. 1915. Geology and Water Resources of Tularosa Basin, New Mexico. United States Geological Survey.
- Melbase, J. 1925. Report on the Gypsum Sands Near Alamogordo, New Mexico.
- Metcalf, A. L. 1984. Distribution of Land Snails of the San Andres and Organ Mountains. *The Southwestern Naturalist* 29:35-44.
- Metzler, E. H., and D. Adamski. 2002. A new species of *Gnorimoschema* Busck, from Ohio and Illinois. *Faberies* 27(1): 59-68.
- Metzler, E. H., and M. Sabourin. 2002. A new species of *Spinipogon* Razowski, from two remnant prairies in Ohio. *Faberies* 27(1):69-76.
- Meyer, D. E. 1959. Studies on background color selection in two species of lizards. Thesis. University of Wisconsin, Madison, WI.
- Meyers, S. 1977. White Sands, New Mexico and Thermoregulation of Several Lizard Species.
- Miles, N. J. 1983. Variation and host specificity in the yucca moth *Tegeticula yuccasella*: a morphometric approach. *Journal of the Lepidopterists' Society* 37: 207-216.
- Miller, R. R., and A. A. Echelle. 1975. *Cyprinodon Tularosa*, a New Cyprinodontid Fish from the Tularosa Basin, New Mexico. *Southwestern Naturalist* 19:365-377.
- Mills, R. 1979. Soil Crust Biomass. In White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report. Laboratory for Environmental Biology, El Paso, TX.
- Mommaerts-Billiet, F. 1971. Note sur lecomorphologie foliaire de quelques plantes gypsicoles d'Espagne. *Bulletin de la Societe Royale de Botanique Belgique* 104:17-27.
- Monger, H. C., and B. J. Buck. 1995. Eolian evolution and paleoenvironmental changes during the late quaternary in the Fort Bliss maneuver areas and vicinity.

- Morgan, G. S., S. G. Lucas, J. W. Hawley, D. W. Love, and R. G. Meyers. 2002. Mammal footprints from Pleistocene Lake Otero, Tularosa Basin, White Sands Missile Range, Dona Ana County, New Mexico. *New Mexico Geology* 24:67.
- Muldavin, E., Y. Chauvin, and G. Harper. 2000. Vegetation of White Sands Missile Range, New Mexico. Produced under cooperative agreement by White Sands Missile Range, United States Fish and Wildlife Service, The Nature Conservancy and University of New Mexico, NM.
- Muldavin, E., G. Harper, P. Neville and Y. Chauvin. 2000. The vegetation of White Sands Missile Range, New Mexico Volume II: Vegetation map.
- Muldavin, E., M. P. Moreno, J. Thompson and P. Melhop. 1994. A Vegetation Map from Satellite Imagery for White Sands National Monument. New Mexico Natural Heritage Program, University of New Mexico, Albuquerque, NM.
- Muldavin, E., P. Mehlhop and New Mexico Natural Heritage Program. 1991. A Preliminary Vegetation Classification and Test Vegetation Map for White Sands Missile Range and San Andres National Wildlife Refuge, NM.
- Muldavin, E., Y. Chauvin and G. Harper. 2000. The vegetation of White Sands Missile Range, New Mexico Volume I: Handbook of vegetation communities.
- Mullis, C. H. 1966. Turbulent Flow Tractive Forces on Granular Bed Materials. Dissertation. University of Oklahoma, Norman, OK.
- Muma, M. H. 1975. Two vernal ground-surface arachnid populations in Tularosa Basin New Mexico. *The Southwestern Naturalist* 20:55-67.
- Murphy, K. A. 1994. Analysis of Near Surface Velocity Gradients to Predict Sand Transport. Thesis. University of Texas at Austin, TX.
- Myers, R. G. 2000. Preliminary draft of selected references of geology and hydrology for White Sands Missile Range and adjacent areas, NM.
- Myers, R. G., and S. C. Sharp. 1989. Biannual Water-Resources Review, White Sands Missile Range, New Mexico, 1986 and 1987. United States Geological Survey.
- Nagihara, S., K. R. Mulligan, and W. Xiong. 2004. Use of a three-dimensional laser scanner to digitally capture the topography of sand dunes in high spatial resolution. *Earth Surface Processes and Landforms* 29:391-400.
- National Park Service Water Resources Division. 1997. Baseline water quality data inventory and analysis: White Sands National Monument. National Park Service Water Resources Division, Fort Collins, CO.

- Needham, C. E., and S. B. Talmage. 1939. Heavy minerals in the white sands of New Mexico. *Pan-Am Geologist* 72:73-74.
- Neher, R. E., and O. F. Bailey. 1970. Soils and Vegetation Inventory of White Sands Missile Range White Sands New Mexico. Soil Conservation Service.
- Neher, R. E., and O. F. Bailey. 1976. Soil survey of White Sands Missile Range, New Mexico: Parts of Dona Ana, Lincoln, Otero, Sierra, and Socorro counties. National Cooperative Soil Survey.
- Norris, K. S., and C. H. Lowe Jr. 1956. A Subspecies of the Lizard *Sceloporus undulatus* from the White Sands of New Mexico. *Herpetologica* 12:125-127.
- Norris, K. S., and C. H. Lowe. 1964. An analysis of background color-matching in amphibians and reptiles. *Ecology* 45:565-580.
- Norris, S., B. Howe, T. Mitchusson, H. Reiser, S. Williams, R. Legler, and G. Garbor. 2005. Coordinated implementation plan for bird conservation in western New Mexico. New Mexico Steering Committee, Intermountain West Joint Venture.
- Orr, B. R., and R. G. Myers. 1986. Water resources in basin-fill deposits in the Tularosa Basin, New Mexico. US Geological Survey, Albuquerque, NM. Water-Resources Investigations 85-4219.
- Otte, C. Jr. 1959. Late Pennsylvanian and Early Permian Stratigraphy of the Northern Sacramento Mountains, Otero County, New Mexico. State Bureau of Mines and Mineral Resources and the New Mexico Institute of Mining & Technology, Socorro, NM. Bulletin 50.
- Parsons, R. F. 1976. Gypsophily in plants - a review. *The American Midland Naturalist* 96:1-20.
- Patrick, G. R. 1979. Dune Crest Vegetation at White Sands National Monument. In White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report. Laboratory for Environmental Biology, El Paso, TX.
- Patrick, G. R. 1979. Insect Activity Cycles. In White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report. Laboratory for Environmental Biology, El Paso, TX.
- Patrick, G. R. 1979. Seed Germination of *Rhus aromatica* and *Yucca elata* from White Sands National Monument. In White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report. Laboratory for Environmental Biology, El Paso, TX.

Patrick, G. R. 1980. Plant succession in the gypsum dune field of White Sands National Monument. Thesis. University of Texas at El Paso, TX.

Patrick, G. R. 1980. Succession behind parabolic dunes. In Final Report: White Sands National Monument natural resources and ecosystem analysis: Volume 1, report of studies. University of Texas at El Paso, Laboratory for Environmental Biology.

Patrick, G. R., and W. H. Reid. 1979. Dune crest vegetation at White Sands National Monument. *Journal of Colorado-Wyoming Academic Science* 11:34.

Patrick, G. R., and W. H. Reid. 1980. Plant succession in the parabolic interdunes at White Sands National Monument. *Journal of the Arizona-Nevada Academy of Science* 15:12-13.

Patrick, G. R., R. Lozano, and W. H. Reid. 1980. Final Report: White Sands National Monument Natural Resources and Ecosystem Analysis, [Contract] CX 702900001 Volume 1, Report of Studies. University of Texas, El Paso, TX. Laboratory for Environmental Biology, Research Report 12.

Patrick, G. R., W. H. Reid, and S. Helfert. 1977. Preliminary Survey of Lake Lucero and Playa Crustaceans and Protozoans. Laboratory for Environmental Biology, El Paso, TX. Research Report 3.

Pellmyr, O. 1999. Systematic revision of the *Tegeticula yuccasella* complex north of Mexico. *Systematic Entomology* 24:243-271.

Pellmyr, O., and C.J. Huth. 1994. Evolutionary stability of mutualism between yuccas and yucca moths. *Nature* 372:257-260.

Pellmyr, O., J. Leebens-Mack, and C.J. Huth. 1996. Non-mutualistic yucca moths and their evolutionary consequences. *Nature* 380:155-156.

Pellmyr, O., J.N. Thompson, J. Brown, and R.G. Harrison. 1996. Evolution of pollination and mutualism in the yucca moth lineage. *American Naturalist* 148:827-847.

Peterson, R. S., and E. Rasmussen. 1983. Research natural areas in New Mexico. New Mexico Natural History Institute, Santa Fe, NM.

Pierce, D. A. 1961. Biological evaluation buck moth infestation White Sands National Monument.

Powell, A. M., and B. L. Turner. 1977. Aspects of the plant biology of the gypsum outcrops of the Chihuahuan Desert. Transactions of the Symposium on the Biological Resources of the Chihuahuan Desert Region, United States and Mexico. Sul Ross State University, Alpine, TX, National Park Service, Washington, DC.

- Pray, L. C. 1954. Outline of the Stratigraphy and Structure of the Sacramento Mountain Escarpment. In Guidebook to Southeastern New Mexico. New Mexico Geological Society.
- Pray, L. C. 1961. Geology of the Sacramento Mountains Escarpment, Otero County, New Mexico. New Mexico Bureau of Mines and Mineral Resources.
- Prival, D., and M. Goode. 2005. Chihuahuan Desert National Parks reptile and amphibian inventory: Final report.
- Prival, D., J. Borgmeyer, and M. Goode. 2003. Chihuahuan Desert national parks reptile and amphibian inventory - 2003: Annual report. Desert Southwest Cooperative Ecosystems Studies Unit, University of Arizona, Tucson, AZ.
- Propst, D. L. 1990. White Sands Pupfish Conservation Plan. New Mexico Department of Game and Fish, Santa Fe, NM.
- Quammen, D. 1985. Yin and Yang in the Tularosa Basin. *Audubon* 87:50-79.
- Razak, K. A., and Z. M. Fuzessery. 2002. Functional organization of the Pallid Bat auditory cortex: Emphasis on binaural organization. *Journal of Neurophysiology* 87:72-86.
- Razak, K. A., Z. M. Fuzessery, and T. D. Lohuis. 1999. Single Cortical Neurons Serve Both Echolocation and Passive Sound Localization. *The Journal of Neurophysiology; Rapid Communication* 81:1438-1442.
- Reid, W. H. 1979. Catalog of White Sands National Monument Plant Specimens. University of Texas El Paso, El Paso, TX.
- Reid, W. H. 1979. Cottonwood distribution and ground water. In White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report. Laboratory for Environmental Biology, El Paso, TX.
- Reid, W. H. 1979. Grain Size Preliminary Study. In White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report. Laboratory for Environmental Biology, El Paso, TX.
- Reid, W. H. 1979. Microenvironment. In White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report. Laboratory for Environmental Biology, El Paso, TX.
- Reid, W. H. 1979. Plant Species. In White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report. Laboratory for Environmental Biology, El Paso, TX.

Reid, W. H. 1979. Soil Properties/Soil Chemistry. In White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report. Laboratory for Environmental Biology, El Paso, TX.

Reid, W. H. 1979. White Sands National Monument Natural Resources Inventory and Analyses, Contract CX 702980023, Final Report. University of Texas, El Paso, TX. Laboratory for Environmental Biology, Research Report Number 11.

Reid, W. H. 1980. Vegetation, physical environment and disturbance in White Sands National Monument. Final Report - White Sands National Monument Natural Resources and Ecosystems Analysis CX 702900001, 1:89-101.

Reid, W. H. 1980. Vegetative Structure, Physical Environment and Disturbance in White Sands National Monument, New Mexico. Proceedings of the Second Conference on Scientific Research in the National Parks, San Francisco, CA.

Reid, W. H. 1989. Precipitation Data for White Sands National Monument for the Period 1978-1987. University of Texas, El Paso, TX.

Reid, W. H., and J. E. Davis. 1999. A quick reexamination of Claret Cup Cactus at White Sands National Monument. White Sands National Monument, Holloman Air Force Base, NM.

Reid, W. H., and P. Sensiba. 1988. Growth and survivorship of Claret Cup Cactus at White Sands between 1978 and 1987.

Reid, W. H., D. L. Hogg, and G. R. Patrick. 1979. Structure of Plant Associations within White Sands National Monument. *Journal of the Colorado-Wyoming Academy of Sciences*.

Reid, W. H., G. R. Patrick, and R. Lozano. 1981. Additions to the Cactus Flora of White Sands National Monument, New Mexico. *Southwestern Naturalist* 26:205-207.

Reid, W., R. Lozano, and R. Odom. 1983. Non-Equilibrium Population Structure in Three Chihuahuan Desert Cacti. *Southwestern Naturalist* 28:115-117.

Reiser, H. P. 2005. Summary of bird observations in White Sands National Monument conducted by John Mangimelli.

Reza, A. 1992. The Scorpions of White Sands. In *Ecological Research at White Sands National Monument During 1992*. Biology Department University of Texas at El Paso, El Paso, TX.

Rosenblum, E. B. 2005. Evolution in black and white: A community scale analysis of adaptation, ecological gradients, and the genetics of reptile color variation. Dissertation. University of California, Berkeley, CA.

- Rosenblum, E. B. 2006. Convergent evolution and divergent selection: Lizards at the White Sands ecotone. *The American Naturalist* 167:1-15.
- Royce, C. L. 1979. Growth and Phenology of *Abronia Angustifolia* Greene in Southern New Mexico. *Journal of the Colorado-Wyoming Academy of Sciences*.
- Royce, C. L. 1980. Ecotypic Differentiation in Annual and Perennial Populations of *Abronia Angustifolia* Greene. Thesis. New Mexico State University, Las Cruces, NM.
- Royce, C. L., and G. L. Cunningham. 1982. The Ecology of *Abronia angustifolia* Greene I Phenology and Perennation. *Southwestern Naturalist* 27:413-423.
- Sachs, M. S. 1970. Saline Groundwater Resources of the Tularosa Basin, New Mexico. US Department of the Interior, Office of Saline Water. Research and Development Progress Report 561.
- Sakai, H., S. S. Shannon Jr., and O. Matsubaya. 1976. Interpretation of the regimen of ephemeral gypsiferous lakes in the Tularosa Basin, New Mexico, using 34 S/32 S, 18 O/16 O, and DH ratios.
- Sandeen, W. M. 1954. Geology of the Tularosa Basin, Southeastern New Mexico. In *Guidebook to Southeastern New Mexico*. New Mexico Geological Society.
- Santos, P. F., and W. G. Whitford. 1983. Seasonal and spatial variation in the soil microarthropod fauna of the White Sands National Monument. *The Southwestern Naturalist* 28:417-421.
- Santos, P. F., and W. G. Whitford. 1983. The Influence of Soil Biota on Decomposition of Plant Material in a Gypsum Sand Dune Habitat. *Southwestern Naturalist* 28:423-427 p.
- Schaffner, E. R. 1948. Flora of the White Sands National Monument of New Mexico. Thesis. Texas A & M College, TX.
- Schenk, C. J., and S. G. Fryberger. 1988. Early Diagenesis of Eolian Dune and Interdune Sands at White Sands, NM. *Sedimentary Geology* 55:109-120.
- Schmidt, R. H. Jr. 1979. A climatic delineation of the real Chihuahuan Desert. *Journal of Arid Environments* 2:243-250.
- Schneider-Hector, D. 1993. *White Sands: the history of a national monument*. University of New Mexico Press, Albuquerque, NM.
- Schoenly, K. 1979. Granivore Communities at White Sands National Monument. In *White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report*. Laboratory for Environmental Biology, El Paso, TX.

- Schoenly, K. 1979. Preliminary Analysis of Algae at White Sands National Monument. In White Sands National Monument Natural Resources Inventory and Analyses Contract CX 702980023, Final Report. Laboratory for Environmental Biology, El Paso, TX.
- Schoenly, K. 1981. Dynamics of a desert carrion arthropod community. Thesis. University of Texas at El Paso, El Paso, TX.
- Schoenly, K., and W. Reid. 1983. Community structure of carrion arthropods in the Chihuahuan Desert. *Journal of Arid Environments* 6:253-263.
- Seager, W.R. 1980. Quaternary Fault system in the Tularosa and Heuco Basins, Southern New Mexico and west Texas: New Mexico Geological Society, Guidebook 31.
- Seager, W.R. 1981. Geology of the Organ Mountains and southern San Andres Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 36.
- Shields, L. M. 1951. Leaf Xeromorphy. In *Dicotyledon Species from a Gypsum Sand Deposit*. *American Journal of Botany* 38:175-190.
- Shields, L. M. 1953. Gross modifications in certain plant species tolerant of calcium sulfate dunes. *American Midland Naturalist* 50:224-237.
- Shields, L. M. 1956. Zonation of vegetation within the Tularosa Basin, New Mexico. *The Southwestern Naturalist* 1:49-68.
- Shields, L. M., and W. K. Mangum. 1954. Leaf nitrogen in relation to structure of leaves of plants growing in gypsum sand. *Phytomorphology* 4:27-38.
- Shields, L. M., C. Mitchell, and F. Drouet. 1957. Algae and Lichen Stabilized Surface Crusts as Soil Nitrogen Sources. *American Journal of Botany* 44:489-498.
- Simpson, E. B. 1983. Preservability of dune and interdune sediments, White Sands, New Mexico. Abstracts with Programs Geological Society of America. Salt Lake City, UT.
- Simpson, E. L. 1983. The Geometry and Structure of Interdune Deposits at White Sands National Monument, New Mexico. Thesis. University of Nebraska, Lincoln, NE.
- Simpson, E. L., and D. B. Loope. 1985. Amalgamated interdune deposits, White Sands, New Mexico. *Journal of Sedimentary Petrology* 55:361-365.
- Sissom, W. D., and O. F. Francke. 1981. Scorpions of the genus *Paruroctonus* from New Mexico and Texas. *Journal of Arachnology* 9:93-108.

- Smartt, R. 1979. Food Habits of Innerdune and Dune Margin Rodents at White Sands National Monument. In White Sands National Monument Natural Resources Inventory and Analysis Contract CX 702980023, Final Report. Laboratory for Environmental Biology, El Paso, TX.
- Smith, H. M. 1943. The White Sands Earless Lizard. Zoological Series Field Museum of Natural History 24:339-344.
- Sprester, F. R. 1980. Hydrologic Evaluation of Garton Lake, White Sands National Monument, NM. Holloman Air Force Base, NM.
- Stone, R. W., N. H. Darton, and Et Al. 1920. Gypsum Deposits of the United States New Mexico. Bulletin US Geological Survey 697:161-186.
- Stroud, C. P. 1949. A white spade-foot toad from the New Mexico White Sands. Copeia 1949:232.
- Stroud, C. P. 1950. A Survey of the Insects of White Sands National Monument, Tularosa Basin, New Mexico. American Midland Naturalist 44:659-677.
- Stroud, C. P., and H. F. Strohecker. 1949. Notes on White Sands Gryllacrididae. Proceedings of the Entomology Society Washington 51:125-126.
- Strohecker, H. F. 1947. Some southwestern Gryllacrididae. Annals of the Entomological Society of America 40: 241-246.
- Sublette, J. E., M. D. Hatch, and M. Sublette. 1990. *Cyprinodon tularosa* Miller and Echelle - White Sands pupfish. In The Fishes of New Mexico. University of New Mexico Press, NM.
- Suminski, R. R. 1977. Life History of the White Sands Pupfish and Distribution of Cyprinodon in New Mexico. Thesis. New Mexico State University, Albuquerque, NM.
- Sweet, M. L., and G. Kocurek. 1990. An empirical model of aeolian dune lee-face airflow. Sedimentology 37:1023-1038.
- Talmadge, S. B. 1933. Source and growth of the white sands of New Mexico. Pan-Am Geologist 60:304.
- Talmage, S. B., and T. P. Wooten. 1937. The non-metallic mineral resources of New Mexico and their economic features. New Mexico Bureau of Mines.
- Thomaidis, C. 1983. Behavior and food habits of the turkey vulture in the northern Chihuahuan Desert. Thesis. University of Texas at El Paso, El Paso, TX.

Thomaidēs, C., R. Valdez, W. H. Reid, and R. Raitt. 1989. Food habits of turkey vultures in West Texas. *Journal of Raptor Research*. 23:14-23.

Triplehorn, C. A. and N. F. Johnson. 2004. *Borror and DeLong's Introduction to the Study of Insects*, Seventh Edition. Thomson, Brooks and Cole, Belmont, CA.

Tucker, R. W. 1977. *Differentiation of Sedimentary Environments by Statistical Methods*. Thesis. Washington State University, WA.

Turner, P. R. 1987. *Ecology and Management Needs of the White Sands Pupfish in the Tularosa Basin of New Mexico*. New Mexico State University, Las Cruces, NM. US Department of the Army, Contract DAAD07-84-M2242.

US Geological Survey. 2000. *Level I Water-Quality Inventory, White Sands National Monument, NM*.

Vandiver, V. W. 1936. *Southwestern Monuments Special Report 5: White Sands Geological Report*.

Varney, R. A., K. Puseman, L. S. Cummings, and L. Beuthel. 2003. *Pollen and macrofloral analysis of several hearth features from White Sands National Monument, NM*.

Vasquez, D. A. 1983. *Notes on the ecology of the Pediocactus papyracanthus at White Sands National Monument, NM*.

Welsh, M. 1995. *Dunes and dreams: A history of White Sands National Monument*. National Park Service, Intermountain Cultural Resource Center, Santa Fe. Professional Paper 55.

West, S. 1985. *Vertebrate fauna of the gypsum dunes and surrounding grassland Hudspeth County, TX*.

Whitford, W. G. 2002. *Ecology of desert systems*. Academic Press, San Diego, CA.

Worthington, R. D. 2000. *Preliminary inventory of the flora of White Sands National Monument, NM*.