RESOURCE MANAGEMENT PLAN

GREAT SAND DUNES NATIONAL MONUMENT

Recommended by: William E. Wellman — 10/15/92
Superintendent — Date
Great Sand Dunes National Monument

Approved by: Acting Homer F. Rowland — 11/19/92
Regional Director — Date
Rocky Mountain Region

TABLE OF CONTENTS

I. **INTRODUCTION** 1

PURPOSE AND SIGNIFICANCE OF THE NATIONAL MONUMENT
PURPOSE OF THIS PLAN
RESOURCE MANAGEMENT OBJECTIVES
MAP OF THE MONUMENT

II. **PRESENT STATUS OF RESOURCES** 3

NATURAL RESOURCES 3
- Sand Dunes
- Water
- Air
- Weather and Climate
- Flora/Fauna
- Wilderness

NATURAL RESOURCES BASELINE INFORMATION 8
- Geological (Sand Dunes/General Geology)
- Water
- Air
- Meteorology
- Biological (Flora/Fauna)

CULTURAL RESOURCES 15
- Archeological Sites
- Structures
- Museum Objects
- Cultural Landscapes
- Ethnographic Resources

CULTURAL RESOURCES BASELINE INFORMATION 18

CULTURAL CONTEXT/THEME 18

III. **RESOURCES MANAGEMENT PROGRAM** 20

OVERVIEW OF CURRENT PROGRAM AND NEEDS 20

MAJOR RESOURCE ISSUES 20
- Baseline Data
- Adverse Water Development
- Low Altitude Aircraft
- Mining Development
- Grazing Trespass
- Wilderness Management
- Medano Corridor Management
- Cultural Resources Protection
- Vegetation Management
- Wildlife Management
- Wildfire Management

STATUS OF RESOURCE MANAGEMENT CAPABILITIES 31
Staffing

TABLE 1. NPS Resource Personnel
TABLE 2. Current Year Resources Funding
PROGRAMMING SHEET 1: Ongoing and Funded Activities
PROGRAMMING SHEET 2: Unfunded Activities

PROJECT STATEMENTS:

NATURAL RESOURCES
GRSA-N-001 FTE for Resources Management
GRSA-N-002 Research Stream & Groundwater Hydrology
GRSA-N-003 Monitor Surface Water Flow
GRSA-N-004 Monitor Groundwater Resources
GRSA-N-005 Monitor Surface Water Quality
GRSA-N-006 Water Resources Management Plan
GRSA-N-007 Study Sand Migration & Wind Patterns
GRSA-N-008 Study Sand Migration & Wind Patterns
GRSA-N-009 Monitor Dune Movement
GRSA-N-010 Study Role of Water in the Dunes
GRSA-N-011 Establish Vegetation Baseline
GRSA-N-012 Baseline Wildlife Study
GRSA-N-013 Entomological Study
GRSA-N-014 Monitor Air Quality
GRSA-N-015 Geographic Information System
GRSA-N-016 Wilderness Management Plan
GRSA-N-017 Wildland Fire Management Plan
GRSA-N-018 Study Boundary Adjustments
GRSA-N-019 Medano Corridor Management Plan
GRSA-N-020 Mitigate Impact on Medano Road
GRSA-N-021 Livestock Trespass
GRSA-N-022 Alien Vegetation
GRSA-N-023 Integrated Pest Management Plan
GRSA-N-024 Hazard Trees
GRSA-N-025 Human/Deer Interaction
GRSA-N-026 Rehabilitate Campground Resources
GRSA-N-027 Potential Mining Activity
GRSA-N-028 Low Level Aircraft Overflights

CULTURAL RESOURCES
GRSA-C-001 Archeological Survey
GRSA-C-002 Prevent Unlawful Collection
GRSA-C-003 Culturally Peeled Trees
GRSA-C-004 Museum Collection
GRSA-C-005 Historic Structures
GRSA-C-006 Administrative History
GRSA-C-007 Abandoned Mine Hazards
GRSA-C-008 Ethnographic Resources Assessment

IV. APPENDICES

A. CULTURAL RESOURCES DOCUMENTATION CHECKLIST

B. SUMMARY CHARTS FOR CULTURAL RESOURCES
   ARCHEOLOGICAL SITES
   MUSEUM OBJECTS
   STRUCTURES
   CULTURAL LANDSCAPES

C. LIST OF CURRENT RESEARCH PROJECTS

D. REFERENCES CITED

I. INTRODUCTION

PURPOSE AND SIGNIFICANCE OF THE NATIONAL MONUMENT

Great Sand Dunes National Monument was established on March 17, 1932, by Presidential Proclamation No. 1994 "...for the preservation of the great sand dunes and additional features of scenic, scientific and educational interest...." This proclamation further states that the Secretary of Interior"...shall have the supervision, management and control of this monument as provided in the Act of Congress entitled 'AN ACT to establish a National Park Service, and for other purposes'...and acts additional thereto or amendatory thereof."

The main theme is "Eolian Landforms" as outlined in the National Park System Plan. The monument provides an example of geology in action and makes the superlative scenery of the dunes accessible to present and future generations of visitors.

PURPOSE OF THIS PLAN

This resource management plan (RMP) provides direction for the present and future management of the natural and cultural resources of Great Sand Dunes National Monument. It summarizes the purpose of the monument and identifies the significant resource values. It discusses the present condition of these resources and the status of the management program at present.

The plan identifies major resource issues and analyzes needs, problems and concerns. It proposes specific actions to deal with the most urgent needs. These project statements include dollar and manpower requirements and are used to prepare budgets.

As a whole, it provides a way to measure progress and insures continuity and commitment to the long range protection and management of the resources of Great Sand Dunes. To remain effective, it should be modified and refined as needs and conditions change.

RESOURCE MANAGEMENT OBJECTIVES

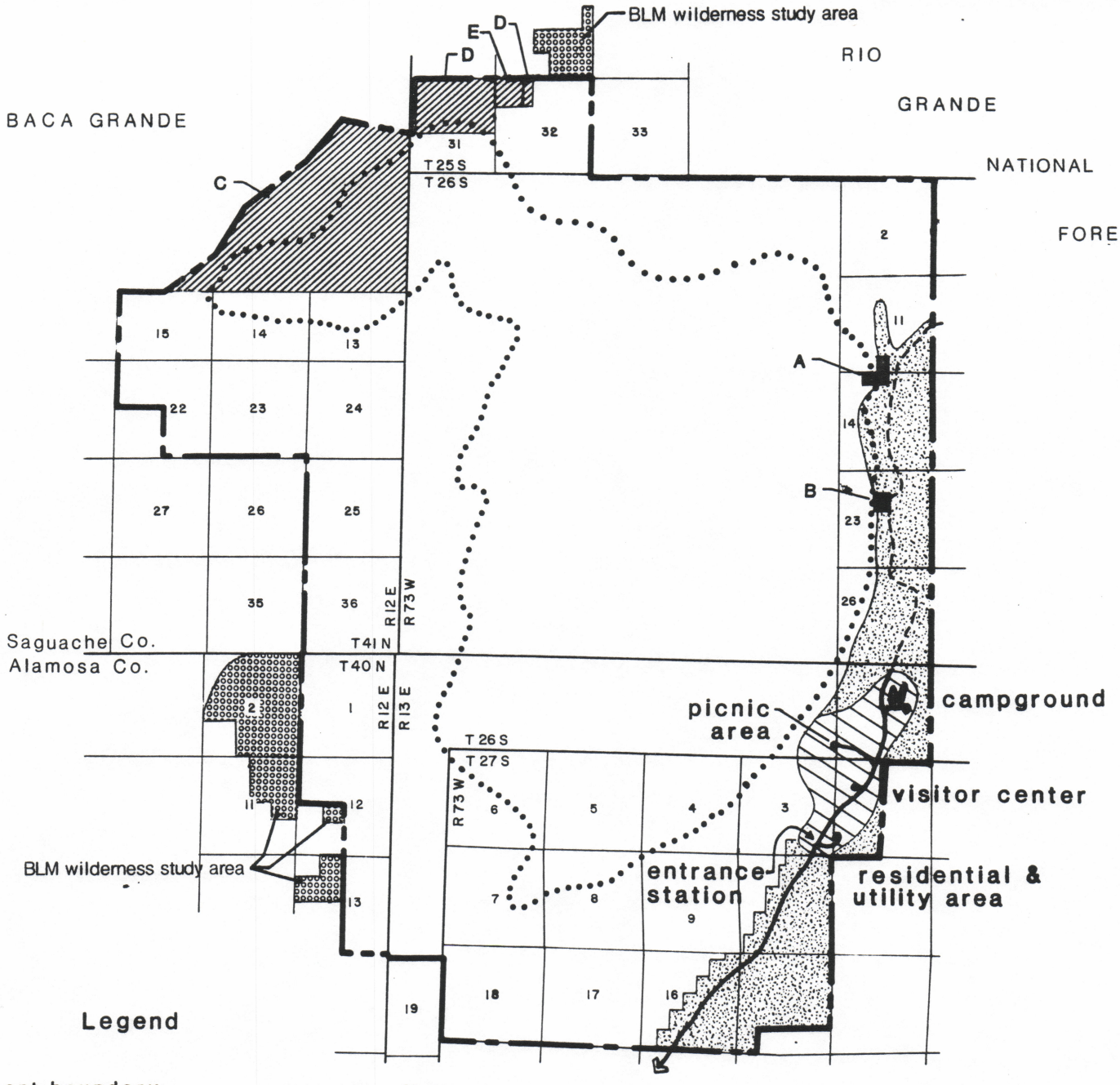
In keeping with the intent of the original proclamation and subsequent planning documents including the current Statement for Management, the resource management strategy for Great Sand Dunes National Monument is to preserve monument's resources. Emphasis will be on understanding and preserving the dunes themselves. The majority of the monument is designated wilderness and these resources will be managed to enhance their wilderness quality.

Objectives: The 1990 Statement for Management lists the following major objectives and issues dealing with park resources:

1. Preserve, protect and interpret the natural resources of Great Sand Dunes National Monument.

2. Preserve, protect and interpret the cultural resources of Great Sand Dunes National Monument.

3. Provide for visitor use and safety at Great Sand Dunes National Monument.



Legend

monument boundary		38,662.18 acres
road		
jeep trail		
main dune masses		24,986 acres
wilderness zone		33,450 acres 87%
development zone		900 acres 2%
natural environment zone		2,076.16 acres 5%
special use - private ownership zone		2,236.02 acres 6%

0 1 2 MILES

0 1 2 3 KILOMETERS

N

Existing Management Zoning Map

Great Sand Dunes National Monument - Colorado

U.S. Dept. of the Interior - National Park Service

Constraints

A. Shockey Reservation ... 31.47 acres
B. Jousma Reservation ... 20.0 acres
C. AWDI Inholding ... 1832.65 acres
D. Simpson / Mitchell Inholding ... 363.37 acres
E. McDaniel Inholding ... 40.0 acres

140 | 80,014-A
Mar 90 | RMRO

II. PRESENT STATUS OF RESOURCES

This section identifies the natural and cultural resources of Great Sand Dunes NM, their significance, and their present condition. The narrative on baseline information serves as a checklist for work that has been accomplished to inventory and monitor these resources, identifying deficiencies where basic data are incomplete or not available.

NATURAL RESOURCES

Sand Dunes

The Great Sand Dunes cover 39 square miles or 65% of the monument's 38,662 acres. They reach heights of over 700 feet, making them the tallest in North America. The dunes dominate the park scene and beautifully represent the interplay of physical forces and geologic processes. As a very compact depositional system they offer an excellent opportunity to study an entire eolian system from source to termination. The location of the sand dunes above a high water table and within a geographic region of extreme weather offers the opportunity to investigate the role that water plays in a desert eolian environment.

The dunes are a dynamic physical system and constitute a continual state of natural disturbance. Even though there is considerable sand movement each time the wind blows, the major dunes remain relatively unchanged. While the exact mechanism controlling dune size and stability is not well understood, current theories credit a combination of the high water table, the sand trap effect of the surrounding mountains and the limiting effect of Medano Creek.

Visitor use (foot traffic) is confined mostly to the dunes along Medano Creek and appears to have no obvious impact on the dunes. In the past, vehicles were driven on the dunes; the extent of this adverse use is unknown, but was probably limited. A mining operation to extract gold dust from the sand existed during the early 1900s, but no visible impact remains except the corner of one concrete footing.

Water

Medano, Mosca, Cold and Sand Creeks, four streams flowing into the monument, constitute much of the water resource. All of these streams sink into the loose sedimentary strata in or near the monument. Several small ponds near the southwestern corner of the monument may be fed by this underground water system. These isolated, shallow water holes support interesting varieties of aquatic life that require additional study.

Medano Creek, as a scientific and recreational resource, rivals the dunes during the spring. It exhibits a consistent surge flow in the portion below Castle Creek. The US Geological Survey (USGS) defines surge flow as a "manifestation of unstable-flow conditions in which a series of translatory waves of perceptible magnitude develops and moves rapidly downstream." Because both a steep gradient and a uniform streambed material (sand) are required, Medano Creek is one of the few streams worldwide which can maintain consistent surge flow.

Beneath the San Luis Valley lies a vast underground water resource, perhaps the Valley's most valuable resource. The system of shallow (unconfined) and deep (confined) aquifers and the related underground controlling structure is not entirely understood. The ground water resources of the monument appear to be intimately linked with the surge flow phenomena displayed by Medano and Sand Creeks, and may play a role in dune stability.

Federal reserved water rights have been adjudicated for the monument including instream flow on all streams flowing into the monument and ground water needed for current and future visitor use. However, average instream flow has not been determined.

The domestic water supply from wells located in the monument is tested regularly and no degradation in quality has been documented. The potential exists for bacteria to enter surface waters from cattle grazing on Mosca and Medano passes and from other natural pathways. Vehicle use in a 3/4 mile section of Medano Creek may impact water quality. Future mining activities could compromise the water quality of Sand Creek.

Air

The vista from the monument across the Valley is spectacular with visibility of more than 60 miles for 180 degrees. The backdrop of the Sangre de Cristo mountains is an integral vista for the sand dunes. Because of the Great Sand Dunes Wilderness, the monument has been established as a Class I area in accordance with the Clean Air Act, as amended, requiring protection of air quality related values from adverse impacts.

Air quality in the monument has historically been excellent. During three years of monitoring (1987-1991), ozone levels rarely exceeded the National Ambient Air Quality Standards.

In 1970, the state maintained a particulate matter sampler at the dunes and the station had an annual average lower than any of the other 50 stations reporting in the state. From 1980 to 1981 a particulate aerosol sampler measured no unusual pollutants. IMPROVE fine particulate samplers have been in place since 1987 with no major pollutants documented other than dust.

The major particulate sources appear to be agricultural burning, fertilizing and pesticide use in the San Luis Valley. Traces of these particulates and fine dust, suspended by high winds, are recorded during the spring months. Six buildings in the monument are equipped with wood burning stoves that could degrade air quality.

Visibility monitoring at a camera station (since 1987) records periods of impairment by dust, especially during the high winds associated with spring weather. During winter, the Valley has low level (less than 100 feet) nighttime and early morning inversions, creating fog and trapping pollution, primarily from home heating. The monument, however, is located above the inversion layer and rarely affected.

Weather and Climate

Although usually not considered a park resource, weather and climate are an integral part of the dynamics of the Great Sand Dunes. As an eolian landform, its origin, morphology and life forms are largely dependent the climatic forces of wind, precipitation and temperature. An understanding of the regional and local (created by the dune field) climatic forces is essential.

Weather conditions are strongly influenced by the adjacent mountains. The 14,000-foot San Juan Mountain Range to the west is an effective barrier to weather systems carrying large amounts of moisture. Average annual precipitation at the monument is only 10 to 11 inches. It is the highest elevation in the US to receive so little moisture (Doesken and McKee, 1989).

Cold air drainage from the mountains results in a mean annual temperature of 42 degrees Fahrenheit, similar to Kodiak, AK, or Williston, ND. Alamosa is frequently the official cold spot in the nation during winter. Located at 8,200 feet, well above the cold air inversion, the monument is typically 8 to 10 degrees warmer. Solar radiation is extreme; there are only about 30 to 40 days a year when clouds obstruct the sun for most of the day.

Consistent south and southwest winds that occur during March, April, May and June commonly reach velocities of 45 miles-per-hour. These constant winds are responsible for the formation of the sand dunes. In summer, the hot surface of the dune mass creates a "heat low" over the dunes, causing acceleration of surface winds.

Heavy storm activity periodically comes out of the northeast, with accompanying winds gusting to 80 miles-per-hour. The geographic lows- Mosca, Medano and Music Passes- provide an outlet as storm fronts collide with the eastern side of the

Sangre de Cristo mountains. Extremely high winds, accelerated by constriction, rush through the passes then die shortly after passing over the dune field. These "reversed" winds are part of the microclimate of the dunes and rarely experienced on the valley floor.

On the sand dunes there is a temperature microclimate marked by extremes. In winter, frost penetration has been measured at four feet beneath the sand. In summer when air temperature is about 80 degrees F., the surface of the sand can be 140 degrees F. At night the sand radiates heat and rapidly becomes colder than the air temperature. The 24 hour temperature range on the surface of the sand can exceed 100 degrees. (Mangemeli, 1981)

The Colorado Climate Center closely monitors climatic trends. Apparently, San Luis Valley data are difficult to interpret. The large variability of winter temperatures (strongly influenced by snowfall) masks any conceivable trends. The one temperature variable that seems to display a trend is diurnal range. The day-night temperature differences appear to be decreasing; the two most likely explanations are increased cloudiness or increased humidity (Doesken and McKee, 1989). It's possible that center-pivot irrigation systems in the Valley are responsible. While increased cloudiness has been documented in other parts of Colorado, no studies have included data from the Valley.

Flora/Fauna

The monument's vegetation and animal life are surprisingly varied for an area dominated by sand. Several species of plants including scurf pea, Indian rice grass, blowout grass and Prairie sunflower are adapted to life on the shifting sands of the dunes. The biotic community of the dunes is dominated by insects and includes the supposed endemic species Cicindela theatina Rotger, the Great Sand Dunes Tiger Beetle, and a darkling beetle, Eloedes hirtipennis Triplehorn.

Coyote, mule deer, Desert and Nutall's Cottontail rabbits, Ord's kangaroo rat, and deer mouse, are common inhabitants of the grassland bordering the dune mass. This habitat contains mixed grass and shrubs, pinyon/juniper forest, stands of ponderosa pine and a limited amount of riparian vegetation. Elk, pronghorn, bighorn sheep, black bear and mountain lion inhabit land adjacent the monument. The monument provides critical winter habitat for several of these animals.

Exotic plant species include Russian Thistle (Salsola kali), Canada Thistle (Cirsium arvense), and Flannel Mullein (Verbascum thapsus), and are primarily limited to roadsides and disturbed areas around developed sites. Both Russian and Canada Thistle have the potential to displace native species and have been

physically removed from several locations. Leafy Spurge has been found on Medano Pass, outside of the monument, and is being controlled and monitored by the US Forest Service (USFS).

At present, exotic animals do not appear to be a problem. Feral cats are trapped/eradicated periodically. House sparrows and European starlings have been observed in the monument, but sightings are rare.

Past human use has permanently changed the environment surrounding the dunes. Early accounts of the area describe a dominant tall grass community. The current vegetation is a community of rabbitbrush, usually indicative of overgrazing. Prior to the establishment of the monument, a small town existed in the vicinity of Mosca Pass and the area was farmed, ranched and logged, primarily for fence posts and buildings materials. Some mining activity occurred in the foothills, mostly small prospect holes. Pronghorn, eliminated by hunting in the 1930s, were reintroduced to the monument in the 1960s.

At present, plant and animal communities appear to be in good condition, however, some localized human impact is occurring. Illegal off-road vehicle use on the Medano Pass corridor and in remote wilderness areas on the north, south, and west boundaries, has damaged fragile desert communities. Bison and cattle trespass occurs on the south and west boundaries, impacting vegetation, seeps and water holes. Vegetation in the campground is impacted and vandalized. Human/deer interaction is an ongoing problem. A small percent (10-20 animals) are aggressive in obtaining food from visitors. The aquatic community of Medano Creek may be impacted by vehicle traffic.

Insect outbreaks may be causing impact to the rabbitbrush and the ponderosa pine. Some of the riparian vegetation along Medano Creek and the dunes parking and picnic areas contains hazardous old growth cottonwood.

Wilderness

A wilderness area comprising 33,450 acres was established for inclusion in the National Wilderness Preservation System through Public Law 94-567 on October 20, 1976. An additional 2,505 acres are designated as potential additions when acquired and/or adverse uses are terminated.

The wilderness area comprises 86% of the monument, the majority of which, is the main dune mass. Accessible only by foot or horseback, most visitor use is contained in a fraction of the entire area and is concentrated around the highest dunes adjacent to Medano Creek.

Frequent winds erase most sign of human use and return the area to a condition similar to that viewed by the first people to visit the area. There are an average of 500 backcountry overnight stays per year, generally concentrated during the months of May through September. Impact from wilderness camping has not been monitored.

The boundaries of the wilderness, being difficult to patrol, monitor and delineate, are subject to impact from grazing and off-road vehicle use. The Medano Creek by-pass on the 4-wheel drive road infringes on the wilderness boundary, compromising wilderness values.

Development activity during the 1980s on the Mitchell property has adversely impacted the wilderness quality of this tract located in the north west area of the monument. This inholding also effectively bars access to Music pass and USFS trails that could network with wilderness routes in the dunes.

The 2,000 foot advisory ceiling for aircraft over Park Service wilderness areas is occasionally violated by military and private planes. Low-level military flights (100 feet), with 3 or more aircraft, occur regularly within the vicinity of the monument. These flights are usually south of the wilderness boundary but sporadic unauthorized overflights of the dune mass are documented.

NATURAL RESOURCES BASELINE INFORMATION

This assessment of current natural resource baseline information uses the standards described in the draft NPS-75, Standards and Guidelines for Natural Resources Inventorying and Monitoring (April, 1988).

GEOLOGICAL

Sand Dunes:
While the dunes have attracted researchers, information is limited. The first study of any consequence was Hayford's (1947), which examined the sand to determine its source. Merk's (1960, 1962) study was more comprehensive, including investigation of the internal structure of the dune ridges. He also examined dune migration, but with no firm conclusions.

Johnson (1967, 1971) described the geomorphology of the dunes and mapped the dune field according to dune types. He also identified the principle source area of the sand.

A variety of short papers have been written about the monument (Burford, 1961; Burford and Hutchinson, 1968; Schaafsma, 1954; Wegmann, 1939), but all of these are primarily descriptive in

nature, and most are concerned only with the source of the dune sand. Alexander (1979) provides a preliminary review of the literature.

Wiegand (1977), was the first study to attempt to determine dune migration and growth. It provides limited measurements for dune movement in the central dune mass, the eastern margin and in the escape dunes. The study also analyzes sand grain size, sorting and mineral composition.

Andrews (1981) sedimentology study used aerial photo analysis, field observation of sand movement, trenching and interpretation of cross-bedding dip directions to conclude that the dune mass is accreting vertically and that dune types are growing in complexity. An earlier work (Andrews, 1978) investigated the geometry and dynamics of the sand dunes.

Fryberger (et al, 1979), documented rates of sand drift and texture of moving sand using an eolian sand trap, and describes the sedimentary features of low-angle sand sheet deposits.

Papers have been written concerning modern eolian deposits, especially as models for understanding ancient eolian environments and their petroleum potential. McKee (1979) and Fryberger, Krystinik, and Schenk (1990) reference the Great Sand Dunes depositional environment, dune morphology, stratification, sand transport and wind regime.

In 1990, the first cores were extracted from the dune mass, providing intermittent samples through 300 feet of sand to 135 feet beneath the current ground level of the dunes (see Appendix C). Studies may yield theories on dune growth rate, climate and wind velocity patterns over time, and may provide a dune chronology with absolute dates. The USGS is attempting to provide an absolute date by determining the last time quartz grains were exposed to light. Preliminary data should be available in 1992.

There is limited data available from a Ground Penetrating Radar study conducted by the USGS in 1989 (see Appendix C). This procedures provides a "map" of the internal structure of a dune down to about 30 meters and over a distance of 100 meters. Work on another section of the dune mass is in progress.

Prior to 1990, there has been no active monitoring program to detect change in the main dune mass. Park staff has monitored escape dune movement in limited surveys (Hasty, 1970; Bunch, Valdez, Wellman, 1991).

A two year sand movement study begun in 1991 will provide data on the transport direction and volume of sand movement throughout the dune mass (see Appendix C). It may yield theories on dune

growth rate and the effect of Medano Creek on the dune mass.

In 1991, the Regional Office provided the first data from a Geographic Information System (GIS). The three dimensional plots of sand thickness indicate one area of extremely thick sand forming a linear feature about 3 miles long oriented toward San Luis Lake. This may prove to be a link between subsurface water and the dunes.

General Geology:
The general stratigraphic framework of the San Luis Valley and physiographic subdivisions have been described by Upson (1939). Considerable work has been done on the geologic history of the Sangre de Cristo range and the Rio Grande rift zone. Assorted geologic papers are available in the monument's library.

The traces of the Sangre de Cristo fault in and near the monument were first described by Upson (1938, 1940), and were later mapped by Kirkham and Rogers (1978, 1981), McCalpin (1981, 1986, 1987) and Colman and others (1981, 1985).

Field work completed by the Colorado School of Mines during the summer of 1991 utilized a variety of remote sensing techniques to locate faults and other subsurface features along the east side of Medano Creek. Report completion is expected in 1992.

A soil survey of the Alamosa Area, including a portion of the Great Sand Dunes is available (Pannell, et. al., 1973).

US Geological Survey topographic map (1:24,000) of the entire dune mass was completed in 1967 and remains relatively accurate. Geologic maps of the dune field and surrounding area are contained in work cited above (Johnson 1967, 1969; Kirkham and Rogers, 1978).

Aerial photographs of the dunes have been taken since the 1930's. Many of these are available from USGS or locally through the Soil Conservation Service (SCS). Photographs currently available at the monument include partial coverage for 1932, 1938, and 1962 and full coverage for 1990.

Status: The baseline data available meet Level I and some Level II standards for geology and basic inventorying for physical features. However, this level has proved inadequate to effectively protect the dunes from external threat and to accurately interpret them to visitors. As defined, the Level of Effort III establishes the nature, time frame, and predictability of natural geologic change, and would determine the physical aspects considered valuable as indicators of change. This is the appropriate level of baseline data needed for Great Sand Dunes.

Studies in progress will help meet this goal, but much remains to be learned about this complex geologic feature. Perpetual monitoring is needed to observe slow geologic processes.

Water

Historically, water resources studies in the monument have been limited to investigation of surface flow, especially, the surging flow demonstrated by Medano creek (Bean, 1977; Schumm, et. al., 1982; Boddie, 1989). Surface water studies such as Roberts' (1958) study of hydraulic geometry of Mosca Creek have been rare. Daniel (1960) investigated ten shallow water holes on the west side of the dunes. The data consists only of pictures and descriptive material about the flora and fauna found in and around the holes.

The ground water resources of the San Luis Valley have been studied more thoroughly. A partial list includes Powell (1958), Emery (1971), Emery and others (1973), Crouch (1980), HRS (1987), Hanna and Harmon (1989), Harmon (1989), and Boddie (1989). Elfrink and others (1989) provides a good summary of the Closed Basin Groundwater Salvage Project which borders the monument to the south and west.

The first analysis of the monument's ground water resources was initiated as part of the 1990 coring project (see Appendix C). Water extracted from the sand cores was analyzed for chemistry. Permanent monitoring wells were installed to record water table fluctuations and permit ongoing water sampling. Two sets of ground water samples have been analyzed for chemistry. The emphasis of this sampling is to determine the chemical signature to trace the source of water to the confined or unconfined aquifer. Down hole geophysical monitoring (gamma, and neutron density logs) was completed in the winter and repeated in the summer. Data should be published in 1992.

Chemical analysis of the monument's surface water also began in 1990. Baseline chemical data have been established for Medano, Mosca, Sand, Buck, Castle and Little Medano Creeks, and Denton and Indian Springs.

An inventory of wetlands in the San Luis Valley was conducted by the Soil Conservation Service and the state of Colorado in 1990-91.

Studies in progress (see Appendix C) will provide baseline information on the surface flow of streams in the monument and data on the relationship of surface flow to ground water.

Status: The data from studies in progress will meet the Level I standard for hydrologic inventorying and monitoring, however, to

protect reserved water rights, automatic gauging (Level III) on at least Medano and Sand Creeks is needed.

To meet the minimum Level I for water chemistry inventorying and monitoring the park needs to inventory rainfall chemistry including pH and conductivity, and complete a bacteriological assessment of all surface waters including analysis for fecal coliform and/or giardia.

Since the water resources monitoring program is relatively new, emphasis should be placed on establishing quality control so that valid comparison of subsequent data can be made. Sampling techniques, storage, chemical analysis, and data interpretation must be standardized.

Air

Air quality in the monument has been monitored periodically since 1970. Mueller (1971) provides data on early particulate matter sampling at the sand dunes and additional pollutant indices and daily patterns from measurements taken at various locations in the Valley during 1970. Data from particulate monitoring in 1980-81 is available.

In March of 1987, a monitoring station was installed to conduct ambient air quality studies. Ozone levels were monitored until October of 1991. Fine particulate monitoring begun in 1987, continues at present, as well as, a camera station that monitors visibility.

Ambient air quality data processing, validation and analysis reports by AeroVironment, Inc., were provided monthly for the entire period of ozone monitoring. Data on particulate monitoring are available from University of California, Davis, Nuclear Lab; visibility monitoring data (35mm slides) are available from Air Resource Specialists in Fort Collins, Colorado.

Status: The available data exceeds the Level I standard for chemical inventory and monitoring of atmospheric gases and particulates.

Meteorology

The unique climate of the San Luis Valley and the Great Sand Dunes has been described by Doesken and McKee (1989) and by Mangimeli (1981). These papers further provide regional weather statistics and investigate geographical influences, including weather patterns created by the dune field.

A dendroclimatologic study (Mangimeli, 1981, 1990) reconstructed the climate for the Great Sand Dunes vicinity over the past 300 years and identified periods of abnormally cool-moist and warm-dry conditions.

A US Weather Station has been maintained at the monument since January, 1951. In May, 1991, the station was relocated and electronic equipment was installed. Temperature, precipitation and unusual weather occurrences are recorded daily. Annual summaries of climatological data are provided by the National Oceanic and Atmospheric Administration and summaries of monthly climatic data are provided by Colorado Climate Center in Fort Collins, Colorado.

From March, 1987 to October, 1991, meteorologic data were logged 24 hours a day by a SUMX data recorder located in the air quality monitoring station. Data include wind speed and direction, temperature, dew point, solar radiation, and precipitation, available in monthly reports from AeroVironment, Inc..

A fire weather station, installed by the USFS and operated by the NPS, monitors temperature, wind speed and direction, humidity and fuel moisture, lightning activity, and current weather conditions, from May through October.

Wind data (speed and direction) from an anemometer located at the Visitor Center, has been gathered 24 hours a day since 1984. Work is in progress to analyze this data. A digital recording instrument will be installed in 1992.

Data from a sand movement study (see Appendix C) will provide additional information about the wind regime within the sand dunes.

Status: The data available meet the Level I standard for meteorologic inventory and monitoring.

BIOLOGICAL

Flora:
Investigations into the flora have been mostly inventories of the accessible part of the monument. The first specific study, by Craft (1960), briefly discusses plant ecology, including adaptation to shifting sand. This study compares plant ecology observed in 1960 with that documented by Ramaley's (1942) study of San Luis Valley flora. Craft's study also includes data from transect studies and a vascular plant list. A general description and inventory of the flora of the San Luis Valley can be found in Dixon (1971).

The list of vascular plants found at the monument was begun in 1953. Entries were identified by Weber (University of Colorado) and herbarium specimens were collected. Updates and herbarium additions have occurred periodically, most recently by the USFS Shrub Research Lab in 1991, including an update of nomenclature.

Vegetation monitoring has not occurred and adequate vegetation maps do not exist. The USFS Shrub Lab study in progress (see Appendix C) will provide baseline data on species distribution and density, a 30 year comparative analysis from aerial photos, will identify new and threatened or endangered species, and species susceptible to damage from a lowered water table.

Fauna:
Fauna studies have also been limited to inventories and descriptive studies of the accessible parts of the monument. Daniel (1960) provides a list of fauna with distribution, a discussion of the sand water biota, and a list of insects and distribution. It also has a good description of the endemic tiger beetle (Cicindela theatina Rotger). A general description and inventory of the fauna of the San Luis Valley can be found in Keen (1971).

A mammal list for the monument is available and was updated in 1985. A bird checklist, based on reported observations from 1950 to 1989, is also available. A two year Mexican Spotted Owl survey began in 1991. Herpetofauna, while limited, has not been adequately studied.

The staff is not aware of any large mammal population, density, or carrying capacity studies conducted in the monument. Alexander (1978) conducted an informal study of Mule deer, mostly behavior observations. Population and distribution of elk, pronghorn, and bighorn sheep on habitat surrounding the monument is monitored by the Colorado Division of Wildlife.

A small mammal survey of the monument was conducted by D. Organ, J. Halfpenny, and T. Folwer in 1977. Limited data exists, but most specimens are available.

The aquatic communities of upper and lower Medano Creek have been described and contrasted by Zuckerman (1984).

A number of short papers discuss and/or list insect populations in the monument (Gregg, 1949; Triplehorn, 1974; O'Neill, date unknown). An extensive survey of insect fauna was conducted in the 1970s by F. M. Brown. Data consists primarily of inventories, not distribution. A good collection exists.

Several insects of special interest have been studied in depth. Tinkham (1962) identified the new genus and species of camel cricket (Daihinibaenetes giganteus) found in the dunes. A

population density study of this camel cricket was conducted in 1983 and 1984 (Sluss, 1984). Data and specimens are available. Gwynne (1979) studied one of two known nesting sites of the Bumblebee Wolf or sand digger wasp (Philanthus bicinctus) and specifically investigated territorial behavior in males.

A survey of dune insects is in progress (see Appendix C) that will provide updated species inventory, density and distribution data.

Status: The data available generally meet the Level I standard for biological inventorying and monitoring. An inventory of herpetofauna and updated inventory of small mammals is needed. A Level of Effort II is needed for endemic insect monitoring, a population model for mule deer, vegetation mapping and long term monitoring, and to determine the role of wildfire in plant communities.

CULTURAL RESOURCES

Documentation of archeological research in Great Sand Dunes NM has been limited and, for this reason, our understanding of the prehistoric human activities within the monument is also limited. We do, however, have a broad knowledge of prehistoric activities in the immediate vicinity of the monument and the San Luis Valley in general.

The earliest known inhabitants of the Great Sand Dunes area were people of the Clovis culture some 11,000 years before present (BP). Folsom sites (10,000 yr BP) have also been found nearby. More recent inhabitants, primarily Utes, used the area around the dunes.

Projectile points, arrowheads, manos and metates suggest occupation from Clovis culture until the mid-1800s, likely small bands of nomadic hunters that came into the valley during the spring, summer and fall, retreating to warmer climates in winter. As far as we know, the first permanent dwellings in the San Luis Valley were log and adobe buildings of 19th century settlers.

The first European to view the dunes may have been Don Diego De Vargas in 1694. Other notable explorers include Pike (1807), who described the dunes vividly in his journal; Beckwith (1853) and Fremont (1848), all of whom passed through or near the sand dunes. Mining on a small scale, logging, ranching and homesteading occurred here in the late 19th and early 20th centuries. During the history of the Mosca Pass Toll Road and Montville townsite, a post office was constructed near what is now the visitor center. Only shreds of previous occupation still remain within the monument boundaries.

Local chapters of the P.E.O. sisterhood are credited with the movement to establish the Great Sand Dunes as a national monument. The families of these P.E.O. members, a few long term residents of the area, and past NPS employees, are still living in the Valley. A complete administrative history of the monument has never been prepared. If a history is to be written, it should be done in the near future while first-hand information on the early days of the monument is still available.

Archeological Sites

Archeologist Joe Ben Wheat was the first to document an archeological site in the monument. Some brief notes describing the site (5AL1) and its location were recorded in 1930 but no further work was done. More extensive investigations were undertaken by E.B. Renaud in 1932 and 1933.

Frank Swancara Jr. undertook a study of the prehistory of the monument in 1954. He visited several sites in the monument, all of which he characterized as blowouts distributed around the perimeter of the main dune area. He also noted the association of all of these sites with water sources and clustering of sites to the west of the dunes. Puebloan ceramics as well as projectile points associated with the Rio Grande Culture (Archaic) were reported from these sites (Swancara 1955).

These early studies focused on the general archeology of the area and on locating sites. Systematic and comprehensive surveys were not conducted and site specific documentation is often insufficient for resource evaluation.

More recent surveys have been conducted in response to development and maintenance projects. Armagast (Zalucha 1976a), and Zalucha (1976b) surveyed portions of the development zone and Johnson (1982) completed a survey of the west boundary fence. In 1986 and 1987 Wayne Williams conducted a survey over the majority of the developed area (Williams, 1990).

A total of 37 sites have been recorded, 36 of which remain unevaluated. Since only a small portion of the monument has been surveyed, it is likely that numerous additional sites exist. Completion of the surface survey is essential.

Many of the sites were subject to surface collection before the creation of the monument. Surface collection and occasional subsurface collection continue to be a problem, particularly in the remote areas of the monument.

Structures

A complete classified structures survey was carried out in 1988. At that time 121 structures were identified at Great Sand Dunes. Of these only the buildings 1 and 2, the original WPA constructed park residence and contact station, were considered eligible for the National Register. In 1989 these two buildings were placed on the National Register of Historic Places. The structures are in good condition and are currently being utilized as the park headquarters and museum storage.

Objects

The monument collection currently contains 6,803 items (includes estimated backlog), the majority of which are biology, archeology and history objects. Through regional funds the cataloging backlog has been virtually eliminated over the past two years. A large collection of monument insects (collected in 1986) was recently received from Fort Lewis College and represents the remaining backlog. This has been contracted and should be completed during 1992. The condition of the collection is generally good.

Storage facilities and curatorial workspace are deficient. Access to the workspace is only possible through the museum storage area. The workspace was previously a bathroom; potential exists for flooding and the area is heated by portable electric heaters. The 1940 building has been adapted to provide a climate controlled environment but is marginal and has no alarm system for fire or theft. The space accommodates the current collection but has no room to expand.

Cultural Landscapes

The largest known group of culturally peeled ponderosa pine trees in Colorado exists at the monument. Research on these scarred trees (Martorano, 1981) documents Native American utilization of bark during the late 18th to early 20th centuries. As of 1990 nearly 100 trees have been identified within the monument. Recent core samples indicate a time frame that correlates with Ute occupation of the San Luis Valley.

Tree bark and bark substances were utilized aboriginally for a variety of functions. Inner bark was used as a food source (both regular and emergency) and for medicinal purposes. Outer bark was used to construct objects such as craddleboards and as a building material for habitations and other structures. Pitch was also utilized as an adhesive and waterproofing agent.

These living artifacts create a difficult resource management situation. The normal life span of a ponderosa pine is approximately 300 to 500 years. Most of the peeled trees in the monument are 300-400 years old. Many of the remaining peeled trees will soon die of natural causes. Others are being damaged by lightning, severe winds, ground fires, insects, disease, vandalism and visitor use on Medano pass road. Several trees directly on the edge of the road have their roots exposed and have been damaged by vehicles. Others have been used by visitors to winch vehicles stuck in the sand.

Ethnographic Resources

The monument has been occupied by various Native American groups for centuries. The Southern Ute Indian Tribe has identified the Great Sand Dunes as a area of special interest having special religious, cultural or historical significance to the Ute Indian people.

An ethnographic overview and assessment has not been completed for the monument and is necessary to determine significance to any other groups and the need for further studies. An assessment would include consultation with traditionally associated groups to determine whether the park has natural or cultural resources of continuing significance to them.

CULTURAL RESOURCES BASELINE INFORMATION

The status of cultural resources is summarized in the Appendices under "Cultural Resources Documentation Checklist" and "Summary Charts for Cultural Resources". Other aspects of cultural baseline information are addressed in the CULTURAL RESOURCES narrative.

CULTURAL CONTEXT/THEME

Cultural Developments of Indigenous American Populations

The Earliest Inhabitants: Clovis (12,000 yr BP);
Folsom (10,000 yr BP)
This theme is represented by nomadic occupation, primarily hunting sites, with fragmented remains of mammoth and bison, lithic scatters, and concentrations of fire-cracked rock. Museum objects include Folsom points.

Prehistoric Archeology: 7,000 yr BP to 500 yr BP

This occupation is represented only by lithic material. Museum objects include Rio Grande points.

Ethnohistory of Indigenous American Populations: 500 yr BP to 100 yr BP

Occupation is evidenced by campsites, lithic material including points, flakes, manos and metates, and scarred trees. Lithic materials are included in the museum collection.

Westward expansion 1800-1930

Scant remains of several homesteads, farming/ranching tools and equipment, historic photos, a canal system, mining equipment, and several shallow prospect holes are the physical evidence of this time period.

III. RESOURCES MANAGEMENT PROGRAM

This is the proposed resources management program for Great Sand Dunes NM. The Overview section discusses the major resource issues and strategies for addressing them. It outlines what the current management program is accomplishing, what is further needed, and assesses the current ability to carry out the entire program. Tables 1 and 2 display current personnel and funding sources for the program; Programming Sheets 1 and 2 display current year budget and personnel requirements for funded and unfunded activities. These activities are specifically outlined in the project statements that follow. These include all of the park's current and anticipated resources management undertakings.

OVERVIEW OF CURRENT PROGRAM AND NEEDS

The resource management program for Great Sand Dunes is, in many ways, in its infancy. Historically, most emphasis was placed on mitigating obvious impacts. Consistent monitoring activities were limited. Much of the monument, being difficult to access, has been neglected in research and monitoring activities. Emphasis is now placed on data gathering that includes the entire monument. The emergence of serious external threats has brought about a more scientific based, active management program.

MAJOR RESOURCE ISSUES:

Baseline Data (Systemwide Issue N20)

Issues:
Even though the monument was established in 1932, much remains unknown about its resources. Sand dunes are not easy to study. Many early researchers experienced data gathering setbacks in the "hostile environment" of the dunes where "...we did not dare to leave the recording instruments where the flying sand could get to them" (Craft, 1960). Studies generated lists and descriptions, not theories, and amounted to what was most easily accomplished.

The problem of how and what to study about the dunes has created the dilemma of approaching the 21st century with mounting internal and external threats and no solid data base from which to make decisions and defend them. A lack of data even makes the accuracy of the interpretive program questionable.

The geologic history of the dunes has not been fully investigated, no specific age has been determined, the role of water within the dunes is not well understood, dune movement is not thoroughly documented over time, internal structure is largely unknown, wind patterns and sand transport throughout the dune mass is undocumented. There is also an inadequate

information base on the interaction between the dunes and vegetation, stream flow and the dunes, and stream flow and ground water. Specifically, we need answers to these questions:

Why is this relatively small dune field the highest in North America?

What is the moisture content of the main dunes, the escape dunes? How is moisture related to dune formation and stability? What is the source of moisture?

What is the internal structure of the dunes? Is it different from the near surface structure? Is there diagenesis in the dunes? Are there clay layers or other impermeable layers in the dunes?

How old are the main dunes? Have there been periods of rapid growth and periods of relative stability? What period are the dunes in now?

Why do the escape dunes move? What is the difference between the escape dunes and the main dunes?

What would be the effect of a drop of 50' to 150' in the water table under the dune field?

What discharge rate is necessary for surge flow to occur on Medano and Sand Creeks?

Where do the creeks cross major fault zones? Are they gaining or losing water into these zones?

What is the relationship between the stream flow of the creeks and the local (unconfined) and regional (confined) ground-water flow systems?

What is the relationship between the discharge of the creeks and moisture content of the dunes, the height of the dunes, and the shape of the dune field?

What are the ground-water flow systems beneath and adjacent to monument lands? What are the directions of ground-water flow? Where are the recharge and discharge areas for ground-water flow system(s) beneath monument lands?

What effect would massive pumping of the confined or unconfined aquifer have on these creeks?

What type of vegetation grows around the dunes? Is it encroaching on the dunes, being replaced by dunes or stable?

Are the vegetated areas within the dunes permanent features?

Or are they temporary or migratory? If permanent, are they moisture dependent?

What effect would a lowered water table have on the vegetation in the monument? In the dune field?

What are the vegetation communities in the monument? What are the members? Are these climax or transitional communities?

How much sand enters the dune field? From what direction? How much sand leaves the dune field? To what direction?

How does the sand move within the dune field?

Is the inflow and outflow in balance? Are the dunes growing or diminishing in height?

Is there a difference in the grain size of the sand entering and leaving the dune field? How much? What happens to the sand that leaves the dune field?

How effective is Medano Creek as a barrier to sand movement? To dune movement? How effective is it as a sand transportation system? What is the net effect of this transportation?

Taken as a whole, what does all this data tell us about a comprehensive theory of the dunes geology?

How can this information best be presented to the scientific community? To monument visitors? To park managers? To the courts?

When the research and monitoring necessary to answer these questions is completed or implemented, then data management and quality control may become an issue.

Strategies and program needs:
A number of research projects were initiated in 1990 to begin to remedy baseline data deficiencies. A list of these projects can be found in the Appendix C. For the first time, we have access to technology like GIS that will integrate data from all of these projects, and we have the ability to core deep into the dunes and date sand samples. New technology may not provide all the answers, but eventually some of these questions will be answered.

In addition to research, several monitoring programs have been initiated to gain baseline data. A sand migration study is attempting to determine wind patterns and sand movement throughout the dune mass.

Monitoring of dune movement, including the escape dunes and the entire main dune mass, must continue. Because ground control is impossible within the main dune mass, all previous dune movement studies have been limited to the edges of the dune field. Using new Global Positioning System (GPS) technology, it is now possible to track dune movement and changes in height at any place in the dune field with an accuracy of one or two meters. When applied, this technology will result in major advances in our understanding of dune dynamics.

A Geographic Information System (GIS) data base for the monument is being compiled through the Rocky Mountain Regional Office. Data management is a growing concern with the sudden development of an active research and monitoring program at the monument. While the park does not have the equipment or staff to build on the data base produced by the regional office, it is likely that Great Sand Dunes will become part of a GIS group based at Curecanti NRA shortly.

Quality control in data collection needs to be addressed. Every long term monitoring program should have standardized, written data collection guidelines.

Adverse Water Development (Systemwide Issues N12, N13)

Issues:
A proposal by American Water Development, Inc. (AWDI), owners of the 100,000 acre Baca Grant adjacent to the northwest corner of the monument, to withdraw 200,000 acre feet of ground water annually, could have major adverse impacts on the natural resources of the monument by lowering the water table 50 to 150 feet beneath the dunes.

This water project is currently involved in complicated legal procedures. The interests of the NPS are being defended by the Department of Justice, Land and Environmental Resources Division. Just prior to the October 1991 trial date, AWDI withdrew their tributary claim to this water, but proceeded with the much weaker non-tributary claim which was denied by the water court. It is generally believed that the tributary claim will be refiled.

A court decreed water diversion on upper Medano Creek is permitted each year from May 15 through July 15. The amount of water diverted is not monitored by the park staff; often water is diverted after the cut-off date. This diversion may impact the aquatic and recreational resources downstream in the monument.

The Bureau of Reclamation (BOR) Closed Basin Water Salvage Project, south and west of the monument, began in the 1970s. It involves a network of shallow wells and canal systems that pump ground water from the unconfined aquifer and transport it to the

Rio Grande river. The environmental impact statement (EIS) for the project determined that the existing water table could be lowered as much as 2 feet at the project's closest boundary (2 to 3 miles southwest of the monument) with no impact to the sand dunes, the existing vegetation, or flows in Medano or Sand Creeks. Continued monitoring is necessary to assure that the project performs as predicted.

Program strategies and needs:
Data from the dunes coring project, monitoring wells, and surface flow studies are helping to develop an understanding of the hydrology of the monument (and its relationship to regional hydrology) and the role that water plays in dune formation and stability. If studies determine a direct relationship between surface flow and ground water and/or between ground water levels and dune geology, a consistent, perpetual monitoring program for surface and ground water resources must become a regularly funded part of the resources management program. At a minimum, surface flow on Medano, Sand and Mosca Creeks must be perpetually monitored to establish average instream flow and protect existing water rights against external activities.

The nature and extent of impact from the upper Medano Creek diversion needs to be studied.

Adverse water development is potentially the most serious threat to the water, geologic, flora and fauna resources of the monument. A comprehensive water resources management plan is needed for the long term protection and management of these resources.

Low Altitude Aircraft (Systemwide Issue N15)

Issues:
A Military Operations Area (MOA) establishing a low altitude training airspace has existed in the San Luis Valley for several decades. Current maneuvers are focused south of the monument at San Luis Lakes. A flight pattern along the east boundary, passing over the mountains at Mosca Pass is common. Sporadic, unauthorized overflights of the dunes occur.

A proposal by the Colorado Air National Guard for a new MOA over the Great Sand Dunes and the northeast San Luis Valley would seriously degrade the natural and aesthetic resources of the monument and its legislated wilderness by permitting low level, tactical flight maneuvers over the dunes. What is now sporadic, would become intensely routine.

Private aircraft occasionally fly low over the dunes, presumably for a "closer look" or for photographic opportunity. An aerial view of the dunes is spectacular. The 2,000 foot advisory

ceiling is not a strong deterrent.

Program strategies and needs:
The NPS and supporting citizen's groups including Friends of the Dunes, Inc. and the Sierra Club have formally opposed the new MOA, known as Project Redeye. Senator Tim Wirth has recommended the proposal be subject to an EIS rather than the environmental assessment (EA) currently in progress.

Action on establishing a minimum altitude to be maintained by aircraft over NPS units (required by Public Law 100-91) is not expected until 1993 at the earliest and will likely be too late to affect the decision on the new MOA. A program of public awareness, especially with park visitors, may be the best strategy at this point.

A formal monitoring program to document the frequency of unauthorized flights is needed. In addition, a record of visitor comments and staff observations on noise levels or potential impact should be kept. The wilderness management plan for the monument, when developed, should address this issue.

Mining Development (Systemwide Issue N10)

Issues:
It is unknown how many tracts of unpatented mining claims exist on the National Forest Service lands on the east and north boundaries of the monument. There is one mining claim in the mouth of Mosca Creek canyon, in the immediate vicinity of the Montville Nature Trail, that could severely damage monument values were it to be developed.

Mining exploration is currently occurring along the north boundary of the monument on both private and Federal land. Most of the interest is in gold extraction through a cyanide leaching process.

Program strategies and needs:
This issue embraces two major areas of concern, outstanding mineral ownership and mining claim related activities. A mining claim study needs to be conducted. Cooperation with the USFS may be essential to mitigation and should be investigated as part of the study. Communication with claimants should be initiated to determine the potential for development.

Grazing Trespass (Systemwide Issue N19)

Issues:
To the immediate south, west, and northwest of the monument are public, private and state lands leased for grazing. Trespass by

bison and cattle occurs regularly, impacting plant communities and soil resources.

It is extremely difficult to maintain fences in sand since the sand routinely covers the fence or blows out from under it. The four strand barbed wire boundary fence is not effective with bison. The boundary fence is compromised so regularly that one water hole, inside the monument, has to be fenced in order to protect archeologic and water resources. The fence around the water hole was damaged the first year and requires frequent maintenance.

Program strategies and needs:
The current fence is patched and repaired, as budget and staff permit, but is only marginally effective where bison graze. Routine patrols and maintenance will be necessary as long as bison are on adjacent land.

Mitigation requires the design and construction of some type of fence that can withstand the environmental conditions.

Purchase of inholdings on the west and northwest would permit relocation of the boundary fence to the Sand Creek drainage which would be easier to maintain.

Wilderness Management (Systemwide Issue N18)

Issues:
Most of Great Sand Dunes NM is wilderness, but no plan exists for its management. The majority of it is so inaccessible, and seems hostile to so many people, that impact from human use may never occur. However, on the boundaries, impact is evident and there are several new areas of concern.

The inability to maintain a boundary fence (see grazing trespass) invites illegal activities. Off-road vehicles (or all terrain vehicles), while prohibited, do enter the monument in remote areas from bordering US Forest Service and BLM land and damage vegetation and dunes. Poaching and cultural resource vandalism probably occurs.

Increased demands on staff have reduced the frequency of boundary patrols; these patrols remove staff from the area all day or overnight.

The NPS has been unable to acquire the Mitchell in-holding within the authorized wilderness boundary. Now, development activity has increased the value to the in-holder, effectively blocked access to Music Pass and the USFS trail system, and degraded the wilderness value of the tract.

Additional threats and impacts to wilderness values are addressed under the issues: Low Altitude Aircraft, Mining Development, Grazing Trespass and Medano Corridor Management.

Strategies and program needs:
The park needs a Wilderness Management Plan that will outline actions to mitigate the external threats of existing and potential mining claim development, low altitude aircraft, and grazing trespass. It should assess the potential for increased backcountry use and determine if or where access and camping should be directed or encouraged. This may include developing a trail system to link with the adjacent National Forest and might require cooperative agreements with the USFS and/or BLM.

Immediate impacts could likely be reduced through increased patrols, educational efforts, and an effective boundary fence, most of which require funding and personnel beyond present capabilities. However, current efforts to mitigate impact must not be further diminished and, when possible, patrols increased.

Medano Corridor Management (Systemwide Issue N22)

Issues:
The Medano Pass 4-wheel drive road, from Pinyon Flats campground to the monument's north boundary, travels along the eastern edge of the dune mass and connects with USFS Road #235. It creates a variety of resource management problems and visitor safety issues.

In sections, the road gets wider every year both from increased use of the one-lane road and from vehicles negotiating others stuck in the sand. Vegetation is lost or damaged. The location of the road is causing impact to several culturally peeled ponderosa pines.

The 3/4 mile bi-pass route through the Medano Creek bed may be causing impact to the aquatic community and water quality. It also permits vehicles inside the wilderness boundary, and raises frequent visitor comment on the inappropriateness of allowing such use.

The very nature of the road creates safety hazards- speed is necessary to travel through the sand, driving in sand and water brings out reckless behavior in some people and extreme conservative behavior in others, and the bi-pass route through the creek places vehicles in conflict with pedestrians.

Strategies and program needs:
Damage along the corridor must be mitigated until alternatives can be investigated. Emphasis has been on trying to control use through barriers and enforcement patrols. Existing barriers need

to be maintained, additional barriers placed as needed, and a regular patrol schedule carried out.

The effects of vehicle use in Medano creek on the aquatic organisms, streambed and bank vegetation must be studied and monitored to determine any adverse impact. Impact to the peeled trees should be monitored and documented. Long term mitigation may require re-location of the road at an estimated cost of $100,000.

Cultural Resources Protection (Systemwide Issues C02,C17,C18,C20 C16)

Issues:
Lack of information concerning archeological and historic resources in the park limits the ability to make sound management decisions and protect cultural resources. An archeological resources survey is only partially completed and identified sites have not been evaluated. Theft of archeological resources may be occurring.

The culturally peeled ponderosa pine trees in the monument require immediate attention. While the trees will eventually die, every effort should be made to preserve them as long as possible and protect them from immediate adverse impacts.

The existing museum storage is inadequate and does not afford the proper protection for the monument's collection.

Strategies and program needs:
An archeological survey of the area around the development zone has been completed. The rest of the monument must be surveyed as soon as possible. All identified sites must be assessed and evaluated. Periodic re-surveying of the dune margins is recommended as sites are exposed or buried by shifting sand.

Sites vulnerable to collection, vandalism, or impact from trespass grazing or human use should be identified and placed on a routine monitoring program. Mitigation might involve public awareness activities, protective fencing, or re-location of conflicting use. Staff training may be necessary to aid in identifying, investigating and preventing archeological theft.

Management of the peeled trees will require monitoring for insect or disease problems, protection from fire and vandalism, and dating to determine vulnerable trees or trees that might be curated. At least one specimen needs to be preserved as a museum object and one as an exhibit for the visitor center, when expanded.

Improved storage and curatorial workspace will be provided in the proposed visitor center expansion. When the collection storage

is planned, the design must include fire detection and suppression, intrusion alarms and fire retardant materials (e.g. carpet and paint).

Vegetation Management (Systemwide Issues N20, N05, N22)

Issues:
Knowledge of the monument's flora is limited to species inventory and general distribution. A comprehensive picture of vegetative trends and patterns, both within the dune mass and in the surrounding grasslands, does not exist. Therefore it's not known if vegetation is controlled by soil moisture, ground water, or the physical effects of the dunes, or a combination of these factors, or something else.

The impact to vegetation within the dune mass from human use (foot traffic, skiing, sledding, horse use) may be a concern. The extent or nature of impact from natural insect infestations is unknown. Specific indicator species, especially for ground water levels, need to be identified and monitored.

Non-native species have been marginally monitored. The extent of the problem needs to investigated more thoroughly and management actions outlined. Inventories have not identified any rare or endangered species, but two species are potentially within the range and habitat found in the monument.

Heavy use of the Pinyon Flats campground has caused vegetation trampling and vandalism, soil compaction and erosion.

Several developed areas in the monument have hazardous trees.

Strategies and program needs:
The first flora inventory of the **entire** monument was completed in 1991, by the USFS Shrub Lab. In addition, the first digitized vegetation maps will be a product of this research. This baseline information provides a starting point from which to measure change and determine trends. Long-term (15-10 years) monitoring of vegetation plots is essential.

Studies are needed to determine the effect and extent of insect larva infestations on the rabbitbrush/grass communities, beetle infestations in the ponderosa pine, and to determine the presence of any other native/non-native insects and related problems.

A Vegetation Management Plan is needed that outlines possible patterns, trends, and controlling factors for vegetation and consequent concerns/management actions. It should establish the specific requirements for the long-term monitoring program. It should provide a course of action for the identification and protection of threatened and endangered plants, and mitigation

measures for non-native plants, insect infestations, and hazardous trees.

An assessment of damage and an action plan to mitigate impact in the campground is needed. Immediate steps should be taken to limit present impact while alternatives such as specific site rotation/closure, or expansion of the campground are investigated. Some of the rehabilitation may accomplished through cyclic maintenance.

Wildlife Management (Systemwide Issue N01)

Issues:
A lack of information about the fauna, especially the deer population, herpetofauna, aquatic communities, and endemic insects, limits the ability to make sound management decisions.

Deer feeding continues to be a problem.

Strategies and program needs:
A number of specific types of inventories have been completed; none are recent or have covered the entire monument. A wildlife baseline study is needed to determine the species, densities and distribution of fauna within the monument, and to determine the presence of any endangered or exotic species that might require management. This study may find the other specific areas or species that need research, such as, the need to determine the carrying capacity for mule deer.

A survey of dune insects is being conducted. It may identify new endemic species that require further study. A long term monitoring program for endemic insects should be designed and implemented.

Present educational strategies and enforcement efforts have not had a noticeable effect in reducing problems with visitors feeding deer. A new approach, including educational materials and signs, or increased enforcement activity, is needed to prevent conflict with visitors and to encourage natural behavior of the deer herd.

Wildfire Management (Systemwide Issue N07)

Issues:
The effects of wildfire on the ecosystem of the monument are unknown.

Present management practice is total fire suppression.

Strategies and program needs:
Little or no data on fire ecology exists for the monument.

Research is needed on the fire history, natural fire regimes, and the effects on flora, fauna, and water resources. Subsequent development a wildfire management plan is scheduled for 1992.

STATUS OF RESOURCE MANAGEMENT CAPABILITIES

Resources management at Great Sand Dunes NM has historically been funded and carried out as part of other park programs. We are making great progress in research and monitoring using regional and servicewide funds. Most of this funding is in response to serious external threats to the primary resources of the monument. To fully understand the resources and to track slow geologic processes will require many years of monitoring and analysis. We can not continue to rely on outside funding. A base funding increase for a full time program is essential.

In order to build on the current research program, Great Sand Dunes needs the capacity to:

1) carry out a long term monitoring program which would continue indefinitely

2) carry out short term studies

3) develop workable resource management/mitigation plans based on research and monitoring results and

4) carry out activities to enhance and protect the natural resources of the monument.

Staffing

A resources management division has never existed; the responsibility for the program has fallen to the Chief Ranger. This position contributes about 0.4 FTE to the resource management program. In 1990, a GS-025-05 (subject to furlough) position was established with 50% resource management duties. The position was upgraded to a GS-025-07 in December of 1991 (with 75% resource management duties). The Visitor Protection division contributes about 0.7 FTE to resource protection type duties. Outside funding sources provided a seasonal geologist for FY91 and FY92. This type of position and skill is very desirable and could be immensely useful for future monitoring programs.

An Operations Evaluation in 1991 identified a critical need for a full time resource management specialist. Without a resource management specialist on the staff it is unlikely that the park would be able to continue the monitoring programs underway. Funds and FTE's have been diverted from other park programs to

carry out the generated workload. For example, $37,000 (7% of the park base) and 1.2 FTE was diverted from other operating divisions to support the resource management activities in Fiscal Year 1992. For Great Sand Dunes to have a viable resources management program a minimum $50,000 base increase and one FTE is needed. To carry out the various long term monitoring programs and research needs identified in the following project statements would require another $20,000 base funding increase.

FY: 92
PARK: GRSA
Region: RMR

TABLE 1
NPS RESOURCE PERSONNEL
(current year only)

TYPE OF NPS EMPLOYEE	FTEs OF RESOURCES WORK		
	Natural	Cultural	Total
Research Scientists			
Resources Specialists			
025 Park Rangers Res Mgmt	1.2		1.2
025 Park Rangers Res Pro	0.7		0.7
025 Park Rangers Res Int			
Maintenance Personnel			
Total of RES Personnel	1.9		1.9
TOTAL PARK FTE: 18.0			
PERCENT	10.6		10.6

TABLE 2

CURRENT YEAR NATURAL AND CULTURAL RESOURCES FUNDING

($ in thousands - funding by activity type)

FY: 92
PARK: GRSA
REGION: RMR

FUNDING SOURCE	TOTAL	RESEARCH DOCUMENTATION	MITIGATION / TREATMENT	MONITORING	PROTECTION	INTERPRETATION	PROGRAM ADMIN / TRAINING
REGN-NR	16.0	16.0					
WATER RES	23.6	11.6		12.0			
PARK-NR	10.0	5.0	2.5		2.5		
AIR QUAL	2.5			2.5			
ALL SOURCES	52.1	32.6	2.5	14.5	2.5		

NATURAL
PROGRAMMING SHEET I
CURRENT YEAR FUNDED ACTIVITIES
($ in thousands)

PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICEWIDE ISSUE	FUNDING SOURCE	ACT TYPE	CURRENT YEAR $$	CURRENT YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE
002	RESEARCH STREAM & GROUND WATER HYDOROLOGY	131		N12 N20	REGN-NR	RES	16.0								16.0	
					WATER RES	RES	11.6								11.6	
			TOTAL FOR ALL ACTIVITIES				27.6								27.6	
003	MONITOR SURFACE WATER FLOW			N13	WATER RES	MON	12.0	0.2							12.0	0.2
					PARK-NR	MON			5.0	0.1	5.0	0.1	5.0	0.1	15.0	0.3
			TOTAL FOR ALL ACTIVITIES				12.0	0.2	5.0	0.1	5.0	0.1	5.0	0.1	27.0	0.5
007	STUDY SAND MIGRATION & WIND PATTERNS	133		N20	PARK-NR	RES	5.0	0.3							5.0	0.3
			TOTAL FOR ALL ACTIVITIES				5.0	0.3							5.0	0.3
014	MONITOR AIR QUALITY			N14	AIR QUAL	MON	2.5	0.1	2.5	0.1	2.5	0.1	2.5	0.1	10.0	0.4

PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICEWIDE ISSUE	FUNDING SOURCE	ACT TYPE	CURRENT YEAR $$	CURRENT YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE
014	MONITOR AIR QUALITY			N14			(CONT'D from previous page)									
	TOTAL FOR ALL ACTIVITIES						2.5	0.1	2.5	0.1	2.5	0.1	2.5	0.1	10.0	0.4
020	MITIGATE IMPACT ON MEDANO ROAD			N22												
					PARK-NR	PRO	2.5	0.1	2.5	0.1	2.5	0.1	2.5	0.1	10.0	0.4
					PARK-NR	MIT	2.5	0.1	2.5	0.1	2.5	0.1	2.5	0.1	10.0	0.4
	TOTAL FOR ALL ACTIVITIES						5.0	0.2	5.0	0.2	5.0	0.2	5.0	0.2	20.0	0.8

CULTURAL
PROGRAMMING SHEET I
CURRENT YEAR FUNDED ACTIVITIES
($ in thousands)

FY: 92
PARK: GRSA
REGION: RMR

PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICEWIDE ISSUE	FUNDING SOURCE	ACT TYPE	CURRENT YEAR $$	CURRENT YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE

PK PRI	PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICE WIDE ISSUES	FUNDING SOURCE	ACT TYPE	STARTING YEAR $$	STARTING YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE
1	001	ESTABLISH FULL TIME RESOURCE MGT POSTION			N24	PARK-NR	ADM	12.5	0.2	12.5	0.2	12.5	0.2	12.5	0.2	50.0	0.8
						PARK-NR	RES	12.5	0.3	12.5	0.3	12.5	0.3	12.5	0.3	50.0	1.2
						PARK-NR	MON	12.5	0.3	12.5	0.3	12.5	0.3	12.5	0.3	50.0	1.2
						PARK-NR	MIT	12.5	0.2	12.5	0.2	12.5	0.2	12.5	0.2	50.0	0.8
		TOTAL FOR ALL ACTIVITIES						50.0	1.0	50.0	1.0	50.0	1.0	50.0	1.0	200.0	4.0
3	004	MONITOR GROUNDWATER RESOURCES			N12	PARK-NR	MON	1.5	0.1	1.5	0.1	1.5	0.1	1.5	0.1	6.0	0.4
		TOTAL FOR ALL ACTIVITIES						1.5	0.1	1.5	0.1	1.5	0.1	1.5	0.1	6.0	0.4
4	005	MONITOR SURFACE WATER QUALITY			N11 N20	PARK-NR	MON	1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1	4.0	0.4
		TOTAL FOR ALL ACTIVITIES						1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1	4.0	0.4
5	006	DEVELOP A WATER RESOURCES MANAGEMENT PLAN FOR GRSA	131		N12 N20	NRNON NPS	ADM	12.0	0.2	5.0	0.1					17.0	0.3

NATURAL
PROGRAMMING SHEET 2
UNFUNDED ACTIVITIES
($ in thousands)

FY: 92
PARK: GRSA
REGION: RMR

PK PRI	PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICE WIDE ISSUES	FUNDING SOURCE	ACT TYPE	STARTING YEAR $$	STARTING YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE
5	006	DEVELOP A WATER RESOURCES	131		N12 N20			(CONT'D from previous page)									
		TOTAL FOR ALL ACTIVITIES						12.0	0.2	5.0	0.1					17.0	0.3
6	008	STUDY SAND MIGRATION AND WIND PATTERNS			N20	PARK-NR	RES	2.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1	5.0	0.4
		TOTAL FOR ALL ACTIVITIES						2.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1	5.0	0.4
7	009	MONITOR DUNE MOVEMENT			N20	PARK-NR	MON	5.0	0.1	5.0	0.1	5.0	0.1	5.0	0.1	20.0	0.4
						REGN-NR	MON					7.5				7.5	
		TOTAL FOR ALL ACTIVITIES						5.0	0.1	5.0	0.1	12.5	0.1	5.0	0.1	27.5	0.4
8	010	STUDY THE ROLE OF WATER IN THE DUNES			N20	REGN-NR	RES	20.0	0.1	20.0	0.1					40.0	0.2
						PARK-NR	MON					5.0	0.3	5.0	0.3	10.0	0.6

PK PRI	PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICE WIDE ISSUES	FUNDING SOURCE	ACT TYPE	STARTING YEAR $$	STARTING YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE
8	010	STUDY THE ROLE OF WATER			N20			(CONT'D from previous page)									
		TOTAL FOR ALL ACTIVITIES						20.0	0.1	20.0	0.1	5.0	0.3	5.0	0.3	50.0	0.8
9	011	DEVELOP VEGETATION BASELINE			N20 N03												
						PARK-NR	MON	5.0	0.1	5.0	0.1	5.0	0.1	5.0	0.1	20.0	0.4
						REGN-NR	RES							20.0		20.0	
		TOTAL FOR ALL ACTIVITIES						5.0	0.1	5.0	0.1	5.0	0.1	25.0	0.1	40.0	0.4
10	012	CONDUCT BASELINE WILDLIFE STUDY			N20												
						REGN-NR	RES	10.0		5.0						15.0	
						PARK-NR	ADM			1.5	0.1					1.5	0.1
						REGN-NR	MIT					1.0	0.1	1.0	0.1	2.0	0.2
		TOTAL FOR ALL ACTIVITIES						10.0		6.5	0.1	1.0	0.1	1.0	0.1	18.5	0.3

PK PRI	PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICE WIDE ISSUES	FUNDING SOURCE	ACT TYPE	STARTING YEAR $$	STARTING YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE
11	013	CONDUCT ENTOMOLOGICAL STUDY			N20												
						NRPP	RES	2.0	0.2							2.0	0.2
						NRNON NPS	RES	9.0								9.0	
						PARK-NR	MON			2.2	0.1	2.2	0.1	2.2	0.1	6.6	0.3
		TOTAL FOR ALL ACTIVITIES						11.0	0.2	2.2	0.1	2.2	0.1	2.2	0.1	17.6	0.5
12	015	DEVELOP A GEOGRAPHIC INFORMATION SYSTEM (GIS)			N20												
						PARK-NR	ADM	50.0	0.3	50.0	0.3	5.0	0.3	5.0	0.3	110.0	1.2
		TOTAL FOR ALL ACTIVITIES						50.0	0.3	50.0	0.3	5.0	0.3	5.0	0.3	110.0	1.2
13	016	DEVELOP WILDERNESS MANAGEMENT PLAN			N18												
						RGNR-OTH	ADM	10.0	0.5	3.0	0.2					13.0	0.7
						PARK-NR	MON					3.6	0.1	3.6	0.1	7.2	0.2
		TOTAL FOR ALL ACTIVITIES						10.0	0.5	3.0	0.2	3.6	0.1	3.6	0.1	20.2	0.9
14	017	DEVELOP WILDFIRE MANAGEMENT PLAN			N07												
						REGN-NR	RES	16.0	0.2							16.0	0.2
						PARK-NR	ADM			2.2	0.1					2.2	0.1
						PARK-NR	MIT					2.0	0.1	0.5	0.1	2.5	0.2

PK PRI	PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICE WIDE ISSUES	FUNDING SOURCE	ACT TYPE	STARTING YEAR $$	STARTING YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE
						PARK-NR	MON					2.0	0.1	0.5		2.5	0.1
		TOTAL FOR ALL ACTIVITIES						16.0	0.2	2.2	0.1	4.0	0.2	1.0	0.1	23.2	0.6
15	018	STUDY BOUNDARY ADJUSTMENTS			N24												
						NWASO-OTH	RES	50.0	1.0	50.0	1.0					100.0	2.0
		TOTAL FOR ALL ACTIVITIES						50.0	1.0	50.0	1.0					100.0	2.0
16	019	DEVELOP MEDANO CORRIDOR MANAGEMENT PLAN			N22 N18												
						PARK-NR	PRO	11.0	0.4	11.0	0.4	11.0	0.4	11.0	0.4	44.0	1.6
						REGN-NR	RES	8.5								8.5	
						REGN-NR	ADM			3.0	0.1					3.0	0.1
							ADM					3.0	0.1			3.0	0.1
						NWASO-OTH	MIT							200.0	0.5	200.0	0.5
		TOTAL FOR ALL ACTIVITIES						19.5	0.4	14.0	0.5	14.0	0.5	211.0	0.9	258.5	2.3
17	021	MONITOR AND PREVENT LIVESTOCK TRESPASS			N19												
						PARK-NR	RES	5.0	0.2							5.0	0.2
						PARK-NR	MIT	7.0	0.1	7.0	0.1	7.0	0.1	7.0	0.1	28.0	0.4
						RGNR-OTH	MIT			64.0	1.5					64.0	1.5

PK PRI	PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICE WIDE ISSUES	FUNDING SOURCE	ACT TYPE	STARTING YEAR $$	STARTING YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE
17	021	MONITOR AND PREVENT			N19			(CONT'D from previous page)									
		TOTAL FOR ALL ACTIVITIES						12.0	0.3	71.0	1.6	7.0	0.1	7.0	0.1	97.0	2.1
18	022	MONITOR AND CONTROL ALIEN VEGETATION			N05												
						PARK-NR	MON	2.0	0.1	2.0	0.1	2.0	0.1	2.0	0.1	8.0	0.4
						NRPP	RES	5.0								5.0	
						PARK-NR	MIT			3.0	0.2	3.0	0.2	3.0	0.2	9.0	0.6
		TOTAL FOR ALL ACTIVITIES						7.0	0.1	5.0	0.3	5.0	0.3	5.0	0.3	22.0	1.0
19	023	DEVELOP INTEGRATED PEST MANAGEMENT PLAN (IPM)			N24												
						PARK-NR	MON	2.0	0.1	2.0	0.1	2.0	0.1	2.0	0.1	8.0	0.4
						NRPP	RES	7.5								7.5	
						PARK-NR	MIT	0.3	0.2	3.0	0.2	3.0	0.2	3.0	0.2	9.3	0.8
		TOTAL FOR ALL ACTIVITIES						9.8	0.3	5.0	0.3	5.0	0.3	5.0	0.3	24.8	1.2

PK PRI	PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICE WIDE ISSUES	FUNDING SOURCE	ACT TYPE	STARTING YEAR $$	STARTING YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE
20	024	MITIGATE HAZARD TREES			N24												
						PARK-NR	MIT	2.0	0.1	2.0	0.1	2.0	0.1	2.0	0.1	8.0	0.4
		TOTAL FOR ALL ACTIVITIES						2.0	0.1	2.0	0.1	2.0	0.1	2.0	0.1	8.0	0.4
21	025	MITIGATE HUMAN/DEER INTERACTION			N24												
						PARK-NR	PRO	2.0	0.1	2.0	0.1	2.0	0.1	2.0	0.1	8.0	0.4
						PARK-NR	MIT	2.0	0.1							2.0	0.1
		TOTAL FOR ALL ACTIVITIES						4.0	0.2	2.0	0.1	2.0	0.1	2.0	0.1	10.0	0.5
22	026	REHABILITATE CAMPGROUND NATURAL RESOURCES			N06 N22												
						PARK-NR	PRO	4.0	0.2	4.0	0.2	4.0	0.2	4.0	0.2	16.0	0.8
						RGNR-OTH	MIT			25.0	1.0	64.0	2.2			89.0	3.2
		TOTAL FOR ALL ACTIVITIES						4.0	0.2	29.0	1.2	68.0	2.4	4.0	0.2	105.0	4.0
23	027	MITIGATE POTENTIAL MINING ACTIVITIY			N10												
						RGNR-OTH	ADM	10.0	0.5	10.0	0.5					20.0	1.0

PK PRI	PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICE WIDE ISSUES	FUNDING SOURCE	ACT TYPE	STARTING YEAR $$	STARTING YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE
23	027	MITIGATE POTENTIAL			N10			(CONT'D from previous page)									
		TOTAL FOR ALL ACTIVITIES						10.0	0.5	10.0	0.5					20.0	1.0
24	028	MITIGATE LOW LEVEL AIRCRAFT OVERFLIGHTS			N15	PARK-NR	ADM	5.0	0.3	1.0	0.1	1.0	0.1	1.0	0.1	8.0	0.6
		TOTAL FOR ALL ACTIVITIES						5.0	0.3	1.0	0.1	1.0	0.1	1.0	0.1	8.0	0.6

CULTURAL
PROGRAMMING SHEET 2
UNFUNDED ACTIVITIES
($ in thousands)

PK PRI	PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICE WIDE ISSUES	FUNDING SOURCE	ACT TYPE	STARTING YEAR $$	STARTING YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE
1	001	CONDUCT ARCHEOLOGICAL RESOURCES SURVEY	115	SITE	C02												
						CWASO-OTH	RES	75.0		50.0		25.0				150.0	
						CWASO-OTH	ADM	15.0		10.0		5.0				30.0	
		TOTAL FOR ALL ACTIVITIES						90.0		60.0		30.0				180.0	
2	002	PREVENT UNLAWFUL ARTIFACT COLLECTION		SITE	C19 C20												
						PARK-CR	PRO	2.7	0.1	2.7	0.1	2.7	0.1	2.7	0.1	10.8	0.4
						PARK-CR	MIT	0.5		0.5		0.5		0.5		2.0	
		TOTAL FOR ALL ACTIVITIES						3.2	0.1	3.2	0.1	3.2	0.1	3.2	0.1	12.8	0.4
3	003	MONITOR AND MANAGE CULTURALLY PEELED TREES		OBJC	C17 C19												
						PARK-CR	MON	1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1	4.0	0.4
						PARK-CR	MIT	2.0	0.1	2.0	0.1	2.0	0.1	2.0	0.1	8.0	0.4
		TOTAL FOR ALL ACTIVITIES						3.0	0.2	3.0	0.2	3.0	0.2	3.0	0.2	12.0	0.8
4	004	MANAGE MUSEUM COLLECTION/ UPGRADE STORAGE FACILITY	103	OBJC	C15 C16												
						PARK-CR	MON	3.0	0.1	3.0	0.1	3.0	0.1	3.0	0.1	12.0	0.4
						REGN-CR	ADM	10.0		3.0	0.2	3.0	0.2	3.0	0.2	19.0	0.6
						CONSTR	MIT					100.0	0.3	100.0	0.3	200.0	0.6

PK PRI	PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICE WIDE ISSUES	FUNDING SOURCE	ACT TYPE	STARTING YEAR $$	STARTING YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE
4	004	MANAGE MUSEUM COLLECTION/	103	OBJC	C15 C16			(CONT'D from previous page)									
		TOTAL FOR ALL ACTIVITIES						13.0	0.1	6.0	0.3	106.0	0.6	106.0	0.6	231.0	1.6
5	005	PRESERVE AND MAINTAIN HISTORIC STRUCTURES		STRC	C06 C12												
						REGN-CR	ADM	4.0	0.2							4.0	0.2
						PARK-CR	MIT			2.0	0.1	2.0	0.1	2.0	0.1	6.0	0.3
		TOTAL FOR ALL ACTIVITIES						4.0	0.2	2.0	0.1	2.0	0.1	2.0	0.1	10.0	0.5
6	006	PREPARE ADMINISTRATIVE HISTORY	128		C08												
						REGN-CR	RES	15.0								15.0	
						REGN-CR	DOC			5.0						5.0	
		TOTAL FOR ALL ACTIVITIES						15.0		5.0						20.0	
7	007	MITIGATE ABANDONED MINE HAZARD		CULL	C11 C21												
						CWASO-OTH	MIT	5.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1	8.0	0.4

CULTURAL
PROGRAMMING SHEET 2
UNFUNDED ACTIVITIES
($ in thousands)

FY: 92
PARK: GRSA
REGION: RMR

PK PRI	PROJ STMT NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICE WIDE ISSUES	FUNDING SOURCE	ACT TYPE	STARTING YEAR $$	STARTING YEAR FTE	OUTYEAR 1 $$	OUTYEAR 1 FTE	OUTYEAR 2 $$	OUTYEAR 2 FTE	OUTYEAR 3 $$	OUTYEAR 3 FTE	TOTAL $$	TOTAL FTE
7	007	MITIGATE ABANDONED MINE		CULL	C11 C21			(CONT'D from previous page)									
		TOTAL FOR ALL ACTIVITIES						5.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1	8.0	0.4
8	008	CONDUCT ETHNOGRAPHIC RESOURCES ASSESSMENT	137	ETHN	C05	CWASO-OTH	RES	30.0								30.0	
		TOTAL FOR ALL ACTIVITIES						30.0								30.0	

APPENDIX A

CULTURAL RESOURCE DOCUMENTATION CHECKLIST

Place an X in the appropriate column. Leave columns blank if document is not required for the park. Remember that items in the first section, PLANNING DOCUMENTS, may also apply to natural resources. See NPS-28, Chapter 2 for description of each inventory or study.

TITLE GREAT SAND DUNES NATIONAL MONUMENT	CURRENT AND APPROVED	INCOMPLETE; NEEDS REVISION OR UPDATING	NEEDED
PLANNING DOCUMENTS			
Preauthorization and Authorization			
Statement for Management (SFM)	X		
Outline of Planning Requirements (OPR)	X		
General Management Plan (GMP)		X	
Development Concept Plan (DCP)			
Resources Management Plan (RMP)	X		
Interpretive Prospectus (IP)		X	
SERVICEWIDE INVENTORIES, LISTS, CATALOGS, AND REGISTERS			
Cultural Resources Bibliography (CRBIB)	X		
Cultural Sites Inventory (CSI)		X	
List of Classified Structures (LCS)	X		
National Catalog of Museum Objects	X		
National Register of Historic Places		X	
BASIC CULTURAL RESOURCE DOCUMENTS			
Archeological Overview and Assessment		X	
Archeological Identification Studies		X	
Archeological Evaluation Studies			X

APPENDIX A

CULTURAL RESOURCE DOCUMENTATION CHECKLIST

TITLE GREAT SAND DUNES NATIONAL MONUMENT	CURRENT AND APPROVED	INCOMPLETE; NEEDS REVISION OR UPDATING	NEEDED
BASIC CULTURAL RESOURCE DOCUMENTS (cont.)			
Ethnographic Overview & Assessment			X
Ethnographic Oral Histories & Life Histories			X
Ethnographic Program			X
Historical Base Map			X
Historic Resource Study (HRS)	X		
Park Administrative History			X
Scope of Collection Statement	X		
SPECIAL RESOURCE STUDIES AND PLANS			
Archeological & Ethno. Collections Studies			
Archeological Data Recovery Studies			
Collection Management Plan			X
Collection Storage Plan			X
Collection Condition Survey			X
Cultural Landscape Report (CLR)			
Ethnohistory			
Exhibit Plan			X
Historic Furnishings Report			
Historic Structure Preservation Guide (HSPG)			X
Historic Structure Report			
Social Impact Study			
Special History Study			
Traditional Use Study			X

GREAT SAND DUNES NATIONAL MONUMENT

SUMMARY CHART FOR ARCHEOLOGICAL SITES

Significance		Condition					Impacts				Documentation		
		Good	Fair	Poor	Destroyed	Unknown	Severe	Moderate	Low	Unknown	Good	Fair	Poor
lational													
State & Regional													
ocal	1					1				1	1		
of valuated	36		2	10		24	6	8	4	18	11	13	12
OTALS	37		2	10		25	6	8	4	19	12	13	12

SUMMARY CH/ ' FOR OBJECTS

DOCUMENTATION Form 10-254 Submitted to National Catalog at Harper's Ferry	Archeology	Ethnology	History	Archives	Biology	Paleontology	Geology	TOTALS
Registration Data Only								
Registration & Catalog Data	523	2	332	42	3832	3	361	5053
Total Items Cataloged	523	2	332	42	3832	3	361	5053
Backlog to be Cataloged	0	0	250*	0	1500**	0	0	1750
Total Collection Summary	523	2	582	42	5332	3	361	6803

* Estimated items at MWAC
** Estimated items

CONDITION The percentage of collection in the following categories	Archeology	Ethnology	History	Archives	Biology	Paleontology	Geology
Excellent							
Good	50%		50%	50%	50%	100%	100%
Fair	50%	100%	50%	50%	20%		
Poor							
Unknown					30%		

GREAT SAND DUNES NATIONAL MONUMENT

SUMMARY CHART FOR STRUCTURES

Significance		Condition				Impacts				Documentation		
		Good	Fair	Poor	Unknown	Severe	Moderate	Low	Unknown	Good	Fair	Poor
National	1	1					1			1		
State & Regional												
Local	2			2		2				1	1	
Not Evaluated	3			3		2	1			2	1	
TOTALS	6	1		5		4	2			4	2	

GREAT SAND DUNES NATIONAL MONUMENT

SUMMARY CHART FOR CULTURAL LANDSCAPES

Significance		Condition				Impacts				Documentation		
		Good	Fair	Poor	Unknown	Severe	Moderate	Low	Unknown	Good	Fair	Poor
National												
State & Regional												
Local												
Not Evaluated	3	1	2					3		3		
TOTALS	3	1	2					3		3		

(Scarred tree sites)

APPENDIX C

LIST OF CURRENT RESEARCH PROJECTS

Dunes Coring The dunes coring field work is essentially complete. A second set of down hole sensing was done in late July and a third set of water samples will be taken this winter. Publication of results is expected sometime in 1992. This research was funded by the NPS Water Right Branch $10,000; RMR Science $5,000; GRSA $2,000; Friends of the Dunes $5,000. BOR provide water analysis. USGS is attempting to date selected cores.

School of Mines The Colorado School of Mines Geophysics Field School used a variety of remote sensing techniques to locate faults and other subsurface features along the east side of Medano Creek. This information will be used in conjunction with the stream flow study to predict the affects of water projects in the valley on the surface flow within the monument. This research was funded by CSM; housing and camping space provided by the park.

Ground Penetrating Radar USGS is using their ground penetrating radar to map subsurface features under Medano Creek near the monitoring hole grid and to dissect a small sand dune. This is the first time the entire internal structure of a dune has been mapped by any technique and should prove valuable to our understanding and interpretation of the dunes. This research is funded by USGS.

Stream Flow Study Dr Jim McCalpin from Utah State University will study the loss of surface flow across fault zones, the relationship of surface flow to ground water and the minimum flow requirements for surge flow on Medano Creek. This is a two year study. Preliminary results indicate that faults are not major factors. This research is funded through the NPS/UW program: $32,000.

Vegetation Mapping The USFS Shrub Science Lab studied monument vegetation to determine vegetative types, map vegetation in the monument, determine extent of vegetation susceptible to impact from a lowered water table, determine if vegetation is encroaching on the dunes and if the vegetated areas in the dunes are permanent features. Field work consisted of examining 120 .01 hectare plots in the monument to determine vegetative type and to establish bases for determining long term changes in vegetation. This research is funded through the NPS/UW program: $5,000 and USFS: $12,000.

Insect Inventory Mike Weissmann of the University of Colorado Museum (and Linda Clement) are conducting an inventory of the dunes insects. This project will collect from both the east and west side of the dune field. It will provide information on the

differences in species and populations across the dune field as well as look at additional endemic species. Funded through CU and RMR Science: $2,000. Park provided housing, camping space and transportation.

Spotted Owl Survey The USFS will be conducting a Mexican Spotted Owl Survey in and around the monument this summer. Historically no Spotted Owls have been observed in the monument. However, one new species of owl was observed last year in the monument and Spotted Owls have been seen on the east side of the Sangre de Cristos. Funded through USFS. Park provided housing and transportation.

Sand Traps/Ground Water Monitoring/Dune Movement Measurements The park staff is monitoring ground water levels in the Medano Creek bed to look at the relationship between surface and subsurface flow.

The park staff is also monitoring the movement of one of the escape dunes (horizontal and vertical profiles) on a monthly basis.

In cooperation with the regional science office, a sand movement study is underway. Twelve sand traps were designed and placed in and around the dune field. The purpose of the study is to determine the direction of sand movement, the ratio of sand entering to sand leaving the dune field by both volume and grain size, and to determine how effective Medano creek is as a barrier to sand movement. This project will be completed during the summer of 1992.

These projects were funded through RMR Science: $5,000, GRSA: $5,000 and Friends of the Dunes: $2,000. BOR analyzed sand size and specific gravity and Adam State College analyzed movement patterns at no cost to the park.

GIS A GIS is being prepared for the monument through the regional office. It will include data from each of the above studies as well as information all ready in existence. GIS was originally perceived as a means of organizing information and producing graphics for court exhibits. We have discovered that GIS is also an excellent analytical tool. Three dimensional plots of the sand thickness revealed that there is only one area of extremely thick sand. The thick sand forms a linear feature about three miles long oriented directly toward San Luis Lake (there is general agreement that the underground flow in the Closed Basin is toward the sump area at San Luis Lake). We are not sure what causes this, but it is a strong indication of a link between subsurface water and the dunes.

APPENDIX D

REFERENCES CITED

Alexander, Byron, 1978, Mule Deer Observations at Great Sand Dunes NM, Unpubl. paper, 19 p.

_____, 1979, Geology of Great Sand Dunes- A preliminary review of the literature, unpubl report, GRSA library, 58 p.

Andrews, Sarah, 1978, Geometry and Dynamics of Great Sand Dunes, San Luis Valley, Colorado: Geol. Soc. of Amer., Abstracts with Programs, v.10.

_____, 1981, Sedimentology of Great Sand Dunes, Colorado in Eolian Depositional System Field Conference, Part II, p.279-291.

AeroVironment, Inc., 1991, Ambient Air Quality Data Processing, Validation, and Analysis, monthly contract reports, GRSA library.

Bean, D.W., 1977, Pulsating Flow in Alluvial Channels: MS thesis, Colorado State University, Fort Collins, CO, 124 p.

Boddie, P.D., 1989, The Great Sand Dunes and the Phenomenal Medano Creek in Harmon, E.J. (ed.) Water in the Valley, Colorado Ground Water Assoc. Guidebook, p.255-260.

Brown, F.M., 1970-, Preliminary investigations and inventories of the insects of Great Sand Dunes, pamphlet file, GRSA.

Bunch, F.L., Valdez, A., Wellman, W.E., 1991, Escape dune migration study and measurements, GRSA.

Burford, A.E., 1961, Petrology of the Great Sand Dunes, Colorado; Proc. W. Va. Acad. Sci., v.33, p.87-90.

Burford, A.E. and Hutchinson, D.M., 1968, Insight into the Origin of the Great Sand Dunes, Colorado (abs): Geol. Soc. of Amer., Special Paper 115, p.28.

Colman, S.M., McCalpin, J., and Ostenaa, D.A.,1981, Morphology of fault scarps in the Rio Grande Rift, Colorado, as an indication of age of faulting, in Junge, W.R. (ed.), Colorado Tectonics, Seismicity, and Earthquake Hazards: Colo. Geol. Survey, Special Pub. 19, p.34-35.

Colman, S.M., McCalpin, J., Ostenaa, D.A. and Kirkham, R.M., 1985, Map showing upper Cenozoic rocks and deposits and Quaternary faults, Rio Grande rift, south central Colorado: US Geological Survey Map I-1594, scale 1:125,000

Craft, J.H., 1960, Adams State College Research Contract for Mission 66 Visitor Center Exhibits, 94 p.

_____, 1960, Plant Ecology, in Adams State College Research Contract, p. 75-94.

Crouch, T.M., Potentiometric surface, 1980, and water-level changes, 1969-1980, in the unconfined valley-fill aquifers of the San Luis Basin, Colorado and New Mexico: US Geol. Survey, Hydrologic Investigations Atlas HA-683, scale 1:250,000

Daniel, J.C., 1960, The Animals of Great Sand Dunes NM and Their General Ecological Position in Craft, J.H., Adams State College Research Contract, p. 51-55.

_____, 1960, Sand Water Biota, in Craft, J.H., Adams State College Research Contract, p. 56-58.

_____, 1960, The Insects of Great Sand Dunes NM, in Craft, J.H., Adams State College Research Contract, p. 59-62.

_____, 1960, The Sand Dunes Tiger Beetle as an Example of Environmental Adaptation and Speciation in the Sand Dunes, in Craft, J.H., Adams State College Research Contract, p. 63-69.

_____, 1960, Winter Avian Fauna of Great Sand Dunes, in Craft, J.H., Adams State College Research Contract, p. 70-72.

_____, 1960, Water Holes, in Craft, J.H., Adams State College Research Contract, p. 73-74.

Dixon, H.N., 1971, Flora of the San Luis Valley, in James, H.L. (ed.) Guidebook of the San Luis Basin, Colorado: New Mexico Geol. Soc., 22nd Field Conference Guidebook, p. 133-136.

Doesken, N.J., McKee, T.B., 1989, The Incredible Climate of the San Luis Valley in Harmon, E.J. (ed.) Colorado Ground-Water Assoc., Water in the Valley Annual Field Trip Guidebook, p.80-98.

Elfrink, L.H., Parsons, L.F., and Demlo, R.E., 1989, San Luis Valley Project, Closed Basin Division, Colorado in Harmon, E.J. (Ed.) Water in the Valley Annual Field Trip Guidebook, p.155-164.

Emery, P.A., 1971, Hydrology of the San Luis Valley, south-central Colorado: US Geol. Survey, Hydrologic Investigations Atlas HA-381, scale 1:250,000

_____, 1971, Water Resources of the San Luis Valley, Colorado in James, H.L. (ed.) Guidebook of the San Luis Basin, Colorado: New Mexico Geol. Soc., 22nd Field Conference Guidebook, p.129-132.

Emery, P.A., Boettcher, A.J., Snipes, R.J., and McIntyre, H.J. Jr, 1973, Water in the San Luis Valley, south-central Colorado: Colo. Water Conserv. Board, Circular 18, 26 p.

Fryberger, S.G., Ahlbrandt, T.S., and Andrews, S., 1979, Origin, Sedimentary features, and significance of low-angle eolian "sand sheet" deposits, Great Sand Dunes NM and vicinity, Colorado in Eolian Depositional System Field Conference, Part II, p.733-746.

Fryberger, S.G., Krystinik, L.F., and Schenk, C.J., 1990, Modern and Ancient Eolian Deposits: Petroleum Exploration and Production: Rocky Mountain Sec., S.E.P.M.

Gregg, R., 1949, Checklist of Ant Species, Great Sand Dunes from "Ants of Colorado", GRSA pamphlet file.

Gwynne, D.T., 1979, Male Territoriality in the Bumblebee Wolf, Philanthus Bicinctus: Ph.D. dissert, Colorado State University, Ft. Collins, CO, 120 p.

Hanna, T.M., and Harmon, E.J., 1989, An Overview of the Historical, Stratigraphic, and Structural Setting of the Aquifer System of the San Luis Valley in Harmon, E.J. (ed.) Water in the Valley Annual Field Trip Guidebook, p.1-34.

Harmon, E.J., 1989, Ground Water Recharge and Discharge in the Confined Aquifers of the San Luis Valley in Harmon, E.J. (ed.) Water in the Valley Annual Field Trip Guidebook, p.35-48.

_____, 1989, Water in the Valley, Colorado Ground Water Assoc. 8th Annual Field Trip Guidebook, 293 p.

Hasty, G.M., 1970, GRSA Dune Migration Study, measurements and maps, Unpubl paper.

Hayford, F.S., 1947, A Petrographic Analysis of the Great Sand Dunes of colorado with conclusions as to Source, MS Thesis, Colorado College.

HRS Water Consultants, Inc., 1987, San Luis Valley Confined Aquifer Study - Phase One, Final Report.

Johnson, Ann M., 1982, Cultural Resource Inventory Along West Boundary Fence Great Sand Dunes NM, National Park Service.

Johnson, R.B., 1967, The Great Sand Dunes of southern Colorado: US Geol. Survey Professional Paper 575-C, p.177-183.

_____, 1971, The Great Sand Dunes of southern Colorado in James, H.L. (ed.) Guidebook of the San Luis Basin, Colorado: New Mexico Geol. Soc. Guidebook, 22nd Field Conference, p.123-128.

Keen, V.F., 1971, Fauna of the San Luis Valley, in James, H.L. (ed.) Guidebook of the San Luis Basin, Colorado: New Mexico Geol. Soc. Guidebook, 22nd Field Conference, p.137-139.

Kirkham, R.M. and Rogers, W.P., 1978, Earthquake potential in Colorado: Colo. Geol. Survey, Open-File Report 78-3, 196 p.

_____, 1981, Earthquake potential in Colorado: Colo. Geol. Survey, Misc. Pub.

Mangemeli, J.A., 1981, The Climate of the Great Sand Dunes NM and Vicinity, unpubl report, 23 p.

_____, 1981, Dendroclimatic Analysis of Upper and Lower Tree-Line Species in the Sangre de Cristo Mountains of Colorado, MS Thesis, University of Nebraska, Lincoln, NE, 114 p.

Martorano, M.A., 1981, Scarred Ponderosa Pine Trees Reflecting Cultural Utilization of Bark, MS Thesis, Colorado State University, Ft. Collins, CO, 127 p.

_____, 1989, Culturally Peeled Ponderosa Pine Trees, GRSA, Saguache Co., CO, Final Report and site forms, G&AI Cultural Resources Report No.40, 25 p.

McCalpin, J., 1981, Quaternary geology and neotectonics of the west flank of the northern Sangre de Cristo Mountains, south-central Colorado: Ph.D. dissert. T-2452, Colo. School of Mines, Golden, CO, 287 p.

_____, 1986, Quaternary tectonics of the Sangre de Cristo and Villa Grove fault zones, in Rogers, W.P. and Kirkham, R.M. (eds.) Contributions to Colorado seismicity and tectonics- A 1986 update: Colo. Geol. Survey, Spec. Pub 28, p.59-64.

_____, 1987, Recurrent Quaternary normal faulting at Major Creek, Colorado-- an example of youthful tectonism on the eastern boundary of the Rio Grande Rift Zone: Geol. Soc. of Amer., Centennial Field Guide, Rocky Mountain Section, p.353-356.

McKee, E.D.,(ed) 1979, A Study of Global Sand Seas: US Geologic Survey Professional Paper 1052, 429 p.

Merk, G.P., 1960, Great Sand Dunes of Colorado in Guide to the Geology of Colorado, Rocky Mtn. Assoc. of Geol., Denver, CO, p127-129.

_____, 1960, Geological Research at Great Sand Dunes NM, CO in Adams State College Research Contract, p.1-50.

_____, 1962, Dune Form and Structure at Great Sand Dunes NM: MS Thesis, University of Colorado, Boulder, CO.

Mueller, T.A., 1971, Results of Preliminary Studies of the Air Pollution Meteorology of Limited Areas in the San Luis Valley in James, H.L. (ed.) Guidebook of the San Luis Basin, Colorado: New Mexico Geol. Soc., 22nd Field Conference Guidebook, p.179-182.

O'Neill, K., date unknown, Insects of the Order Hymenoptera Found at GRSA, unpub pamphlet file, 4 p.

Organ, D. and Halfpenny, 1977, Small Mammal Survey of GRSA, unpub, pamphlet file, GRSA.

Pannell, J.P., Yenter, J.M., Woodyard, S.O., and Mayhugh, R.E., 1973, Soil Survey of Alamosa Area, Colorado: USDA, Soil Conserv. Service, 122p.

Powell, W.J., 1958, Ground water resources of the San Luis Valley, Colorado: US Geol. Survey, Water Supply Paper 1379, 284 p.

Ramaly, F., 1942, Vegetation of the San Luis Valley in Southern Colorado, University of Colorado Studies, Series D.1:4, p.231-277.

Roberts, M.C., 1958, The hydraulic geometry of the middle and upper portions of Mosca Creek, Sangre de Cristo Range, Colorado: Oklahoma Acad. of Sci. Proc. 46:205-212.

Schaafsma, H.F., 1954, Short History of the Great Sand Dunes Area: NPS Report for Region Three, 11 p.

Schumm, S.A., Bean, D.W., and Harvey, M.D., 1982, Bed-form-dependent pulsating flow in Medano Creek, southern Colorado: Earth Surface Processes and Landforms, 7:17-28.

Sluss, T.P., 1983, Population Density Studies of the Sand Treader Cricket at the Great Sand Dunes NM, unpubl report, 8 p.

Swancara, Frank, 1955, The Archaeology of the Great Sand Dunes National Monument, A Preliminary Survey, Southwestern Lore 20(4):53-58.

Tinkham, E.R., 1962, Studies in Nearctic Desert Sand Dune Orthoptera, Part V in Great Basin Naturalist 22, p.12-29.

Triplehorn, B.W., 1974, Insects at Great Sand Dunes, unpubl report, GRSA pamphlet file.

Upson, J.E., 1938, Late Tertiary and Quaternary faulting in the San Luis Valley, Colorado: Geol. Soc. of Amer., Abstracts for 1937, p.316-317.

_____, 1939, Physiographic Subdivisions of the San Luis Valley, Southern Colorado in James, H.L. (ed) Guidebook of the San Luis Basin, Colorado: New Mexico Geol. Soc., 22nd Field Conference Guidebook, p.113-122.

_____, 1940, Pleistocene and recent normal faulting in southern Colorado (abs.): Northwest Science, 14(3):72.

Wegmann, C.H., 1939, Great Sand Dunes of Colorado in Mines Magazine, v. 29, p.445-448.

Wiegand, J.P., 1977, Dune Morphology and Sedimentation at Great Sand Dunes NM: MS Thesis, Colorado State University, Ft. Collins, CO, 165 p.

Williams, Wayne, 1989, Cultural Resources Surveys of Developed Areas, National Park Service.

Zalucha, L. Anthony, 1976a, Trip Report, Archeologic Survey, Great Sand Dunes NM, National Park Service.

_____, 1976b, Archeological Survey Dunes Picnic Area Great Sand Dunes NM, National Park Service.

Zuckerman, L.D., 1984, Limnology of a Seasonally Intermittent Stream Perched on Deep Sand Deposits in Great Sand Dunes NM: Final Report, Colorado Cooperative Fishery Research Unit, 74 p.