DINOSAUR NATIONAL MONUMENT

RESOURCE MANAGEMENT PLAN

Approved: _____
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Superintendent

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- Act of 1916 establishing a National Park Service
- Endangered Species Act
- Fish and Wildlife Coordination Act
- Wilderness Act
- Wild and Scenic Rivers Act
- National Environmental Act of 1967
- Clean Air Act
- National Park System Mining Activity Act of 1976
- Redwood Act of 1978
- Archeological Resources Protection Act of 1979
- National Historic Preservation Act of 1966
- Migratory Bird Treaty Act
- Bald Eagle Act

In addition to the legislated acts listed above that influence resource management actions at Dinosaur, there are also a variety of Executive Orders, a key civil suit dealing with instream flows in the Yampa River, various planning documents, and cooperative agreements with state and Federal resource management agencies. These all have an influence on determining the legal responsibilities of the National Park Service toward natural and cultural resource management within the monument.

The park's General Management Plan (1986) sets forth its primary objectives with the statement that they "are to protect and preserve the natural and cultural environments; to permit biological, geological, and other natural processes to continue with a minimum of human disturbance; and to provide opportunities for enjoyable visitor experiences as well as an understanding of the significance of monument resources." The plan goes on to detail numerous issues and concerns related to resources in the cultural, paleontologic, geologic and biologic fields.

The following general management objectives selected from the current Dinosaur Statement for Management reinforce the objectives contained within the General Management Plan.

Manage all the monuments resources as a total environment to perpetuate the natural, paleontological, historic and prehistoric features for which the area was established.

Consistent with the Land Protection Plan, acquire or otherwise protect private and State inholdings as they become available.

Coordinate and cooperate with other agencies and groups to protect, manage and portray significant regional resources.

Provide staffing sufficient to interpret, protect, manage, and support park resource values.

B. ADMINISTRATION AND MANAGEMENT

Dinosaur National Monument is administered by the Department of Interior within the Rocky Mountain Region of the National Park Service which is headquartered in Lakewood, Colorado.

Access to the park is primarily by way of US Highway 40 which provides an east/west link between Denver, Colorado and Salt Lake City, Utah. In addition, there are north south connections that link with Interstates 70 and 80, thus providing ready access to a wide range of travellers. Adding to the complexity of the area is the fact that it straddles the Colorado/Utah state line.

The monument was visited by approximately 507,600 visitors in 1992. That total set a new annual record for Dinosaur which was matched by mid-October in 1993. The monument has received an average of 439,820 visitors per year for the past ten years (1983 - 1992). Many of the visitors are day users who come primarily to observe the dinosaur remains on display at the Dinosaur Quarry on the Utah side of the monument; however, an ever increasing number of visitors are discovering the rugged back country of the monument and are staying longer to explore the park in greater detail. Another major user group at Dinosaur is made up of the people who participate in whitewater boating in the rugged canyons of the Green and Yampa Rivers. Nearly 35,000 user days are spent on these rivers annually.

C. OBJECTIVES OF THE RESOURCE MANAGEMENT PLAN

The primary intent of this plan is to provide a working foundation for actions necessary to the proper long range management of the natural and cultural resources of Dinosaur National Monument. Among its intended objectives are:

1. A summary overview of the natural and cultural resources of the park with special emphasis upon those resources which relate to the values and purposes of the park.

2. An analysis of both the natural and cultural resource needs and problems ranked according to their importance.

3. A set of proposed actions, including dollar and FTE estimates, specifically aimed at dealing with the most important and urgent of the identified needs and problems.

4. A proposed multi-year program aimed at achieving measurable progress in the accomplishment of the proposed actions.

5. A plan for annual review and recording of accomplishments which will serve as a measure of the effectiveness of

those actions.

The plan is intended to supplement other park documents such as the Dinosaur National Monument General Management Plan and Statement for Management and National Park Service Guidelines which are directed at resource management concerns. It is intended to provide a working foundation which supports the various legal mandates that bear upon resource management actions at Dinosaur; however, it is not intended to be an inflexible document which provides the final word on management of the monument's varied resources. It is designed in a manner which will allow revision and updating of individual portions without the necessity of completely rewriting the entire document.

D. PURPOSE/STRUCTURE OF THE RESOURCE MANAGEMENT PLAN

This Resource Management Plan is a revision of several earlier resource planning documents which dealt with different phases of resource programs within Dinosaur National Monument or with specific projects on a stand alone basis. The intent of this plan is to pull together the diverse, but intertwined needs and requirements of the complex assortment of resources that make up the park. The plan describes the biologic, geologic, paleontologic, historic and prehistoric resources protected within the park boundaries and identifies management activities for preserving those resources. A wide range of research initiatives, baseline studies, and manipulative and protective techniques are integrated into a comprehensive resource management program.

Although the overall plan is basically divided among the two major headings of natural and cultural resources it is important to note that there are a series of subheadings which are essential to understanding the complex resource array that exists within the monument. Natural resources at Dinosaur can normally be divided into biologic, geologic and paleontologic subheadings. The use of "natural resource" will normally be limited to situations in which two or more of the three natural categories are being discussed jointly. Whenever possible, specific reference will be made to biologic resources for all processes involving living organisms and an on-going ecologic process. Likewise, sections involving the fossil resources of the monument will be addressed as paleontologic and those dealing with the formation of the overall land forms will be addressed as geologic. By the same token, "cultural resources" will be addressed in terms of prehistoric and historic when it is appropriate to do so.

II. NATURAL RESOURCES BASELINE INFORMATION

This section summarizes the current status of baseline information existing for all categories of natural resources within Dinosaur National Monument. This includes both the categories of resources such as geology and paleontology which are fixed in time and those which are currently living or subject to rapid change. It identifies major resources, assesses completeness and reliability of baseline inventories, and briefly describes the general condition of those significant resources. More detailed coverages of specific resource categories can be found in Section III under the applicable headings within that section.

A. NATURAL RESOURCE BASELINE INFORMATION

1. VEGETATION

A 3-year inventory of rare plants and the general flora of the monument was conducted by the Colorado Natural Areas Program from 1987 through 1989. This effort was confined to terrestrial vascular plants and concentrated on rare species. Nearly 40 species of rare plants were collected and identified. Naumann (1990) provides species abstracts of all the rare plants indicating federal and State status, distribution, phenology, distinguishing features, habitats and substrates, locations in Dinosaur, significance of populations, taxonomic history and recommendations for management. Included in the final report of the inventory is an extensive database incorporating all species observed, collections, and references to historic collections housed in other repositories. Although the research identified over 650 species, researchers suggest that an additional 200-250 species might be identified with more thorough surveys.

A special study of the federally threatened Spiranthes diluvialis (Ute ladies tresses orchid) began in 1991. This inventory has identified a large population of about 200 individual plants in Hog Canyon. These plants have been individually marked and characterized in a 10-year demographic monitoring program. Several additional small populations have been identified in Island Park, near the Green River campground, in Orchid Draw and along the southwestern flank of Split Mountain.

The distribution of certain components of the general flora (specifically cottonwood and boxelder) has been described by location and age class. Riparian vegetation was inventoried and characterized by Potter et al. (1983). Research began in 1993 to

examine the relationship between river flows and the establishment and maintenance of riparian communities.

General plant associations have been described and mapped to approximately 1 hectare resolution. That data has been digitized and is available for GIS applications.

Inadequate inventories exist on aquatic vegetation and non-vascular plants (algae, lichens, etc.). Some groups of aquatic plants were collected and identified in the early 1960s in conjunction with the construction of Flaming Gorge Dam (Holmgren 1962a, Holmgren 1962b). Those specimens at the park are poorly preserved and may be of little use. Some groups of aquatic vegetation were incidentally identified during research on primary productivity in the Green and Yampa Rivers (Annear 1980). Researchers from Brigham Young University began collections of lichens from upland areas in 1991. The intent of this research is to identify selected species for monitoring of air pollutants. In conjunction with the research, however, are efforts to establish a baseline of species richness and distribution of lichens. Researchers estimate that perhaps 200 species may exist in the monument; completion of the baseline may require an additional two years. Other non-vascular plants have not been inventoried.

Baseline inventories of non-native plants are inadequate. Those species of particular interest and/or concern include tamarisk, cheat grass, Russian knapweed and giant whitetop. Baselines need to be established for wetlands and microbiotic soil crusts.

2. ANIMALS

Bogan et al. (1988) have identified 65 species of recent mammals within the monument (11 species were added to the known fauna in the early 1980s). A few additional species have been recorded since publication of this paper, bringing the total to 68 species, all of which are documented by specimen records or, in the case of large extirpated mammals, by acceptable sight records (old diaries, etc.). This baseline includes some information on species distribution within the monument, but deals only briefly with ecological relationships. Other baseline information is available on bighorn sheep, mule deer, pronghorn antelope, elk and a few of the more prominent species.

Baseline information on birds is largely restricted to a species list and seasonal presence. Both in-park and Colorado and Utah latilongs contribute to the baseline. Information is updated through ongoing fire effects studies and incidental observations. Nearly 220 species have been documented by acceptable sight

records; latilong reports suggest the possible presence of another 20-30 species. Considerably more baseline information exists on peregrine falcons through monitoring and management activities since 1977. Locations of observations, eyrie characterizations, photographs of individual eyries, production and several other parameters are described in detail.

Data and specimen collection for baseline inventories of reptiles and amphibians began in 1991; a final report is expected in 1994. Some more detailed research was conducted on the midget-faded rattlesnake in the 1970s.

Excellent baselines are available on native and non-native fish. The Green and Yampa Rivers contain fish representing 9 families and 26 species. Nine species are native (6 endemic) and 17 species are introduced. Baseline data contributions have been made through extensive studies conducted since the early 1960s (see Wydoski et al. 1980). Intensive studies since 1979 on endangered fishes have identified species composition and distribution by life stage, habitat requirements (flow, substrate, etc.), and ecological relationships (Miller et al. 1982a, Miller et al. 1982b, Tyus et al. 1987, Tyus and Karp 1989, and many others).

Development of an insect inventory is underway through Colorado State University. Some 950 species have been identified including several new records and at least 50 species new to science. Researchers suggest that another 500 species of insects occur in the monument. Aquatic macroinvertebrates were inventoried by Pearson (1967) and Carlson et al. (1979); these baselines should be updated. Arthropods, including soil arthropods are largely uninventoried. Researchers suggest that only about one-quarter of the park's arthropod fauna has been identified and documented by specimen records.

3. AIR RESOURCES

Visibility monitoring with teleradiometers and/or cameras (35mm transparencies) was conducted from 1977 through 1991. Particulate sampling was conducted for approximately 12 months in 1983-1984. Elemental analysis of particulate matter has not been conducted although such data was collected at a site near the monument in the early 1980s. Site-specific data is not available on acid deposition.

4. WATER RESOURCES

A considerable volume of baseline data is available relating to the Green and Yampa Rivers. Studies in the late 1970s and 1980s (Annear 1980, Andrews 1978, Steele et al. 1978, Sumsion 1976, O'Brien 1984, O'Brien and Miller 1984, Elliot et al. 1984, and many others) investigated temperature regimes, sediment transport, flow characteristics, various water chemistry and water quality parameters, and other hydrologic characters. Current research is examining sediment dynamics, with emphasis on its relationship to endangered fish, establishment and maintenance of riparian communities, and river use management (campgrounds, etc.). Other research is examining the magnitude of rainfall events and debris flows into the rivers.

USGS gauging stations provide flow information dating back to the 1920s. A cursory water quality study was completed in 1980 (Envirosphere 1981). Sumsion (1976) compiled scattered data points on locations, discharges (including some flood frequencies), temperatures and water chemistry of certain tributary streams, springs and wells in the monument. A complete inventory and characterization of springs, seeps, perennial streams, intermittent streams and stock ponds needs to be completed.

5. AMBIENT SOUND

An ambient sound baseline was developed by 12 months of sampling at each of 3 locations in the monument from 1989 to 1993. One site was selected as representative of low use, backcountry situations; another represents areas with intermittent moderate human intrusion, and the third is located near an area of persistent high visitor use. At each site, hourly and daily data was collected showing Leq, L1, L10, L50, L90, L99 and Lmin. Analysis of data from all areas show L90 ambient sound levels of only 22-25 decibels.

6. SOILS

An adequate soils inventory has not existed for the monument. The need for such an inventory has been identified as a high priority natural resource need. The only previous data related to soils is from an effort made by the Soil Conservation Service in the 1950s to characterize soils by texture. The Soil Conservation Service, with partial funding by the National Park Service, initiated a major soil survey effort in 1993. Completion of final reports, including digitized soil maps, is scheduled for 1995.

7. OTHER LAND USE BASELINES

A history of authorized grazing use has been compiled for the monument. This compilation notes allotment names, location of base lands, allotment size and location, permittees, maximum preferences, levels of permitted use, transfers of land ownership, percentages of total use, and actual or projected terminations of grazing for the period from 1960 to present. It represents the best summary available on grazing by domestic livestock in the monument.

B. PALEONTOLOGIC RESOURCES BASELINE INFORMATION

With the exception of the Dinosaur Quarry and the Morrison Formation, relatively little is known about the paleontological resources in Dinosaur.

Nothing is known about fossils in the Pre-Cambrian rocks within the monument. Pre-Cambrian fossils are extremely rare worldwide and may well not be present within the monument.

Eight Paleozoic formations occur within Dinosaur. No systematic inventory work has been done for Paleozoic paleontological resources. A few geological studies have described paleontological materials in passing (Driese 1982, Maione 1971, Untermann and Untermann 1954) but such information is scarce and scattered, and the data in these works is not sufficient to serve as adequate baseline data.

Many of the Mesozoic formations within Dinosaur have extensive exposures throughout the southwestern and western U.S. A review of the scientific literature shows that abundant, diverse and significant fossil floras and faunas have been found within all of those formations. In some cases, these faunas are known from exposures immediately adjacent to monument boundaries in horizons which continue into the monument.

No systematic baseline inventory has been completed for any Mesozoic formation within the monument. In 1990 two 3-year contract studies began which focus on systematically inventorying paleontological resources in the Upper Jurassic Morrison Formation. Only preliminary reports are available (Engelmann 1990; Turner & Peterson 1991; but these show that abundant and significant resources do occur. In the first two years of his study, Engelmann identified 300+ paleo localities. However, many of the sites discovered need additional study and analysis to provide complete baseline data on faunal and floral composition of the Morrison. Two localities in the Morrison formation within Dinosaur have produced hundreds of significant remains of the small vertebrates which were contemporaries of the animals preserved in the Dinosaur

Quarry and provide baseline data on the small component of the Morrison fauna (Chure & Engelmann 1989; Chure, Engelmann, & Madsen 1989; Engelmann, Chure, & Madsen 1989; Engelmann, Greenwald, Callison, & Chure 1990). However, many collected specimens require additional analysis. Pollen and spore analysis is currently underway on Morrison samples, although complete analysis of the material awaits additional funding. These studies promise to produce significant information on the Morrison flora. In summary, the Morrison formation contains the best documented fossil resources, in terms of distribution of sites. However, additional studies are needed, to adequately evaluate the significance of the materials collected from and still in the ground at these site. Nevertheless, the Morrison should serve as a model for other formations.

Because of its location within the Visitor Center and the policy of leaving the fossils in-situ, the Dinosaur Quarry constitutes a special kind of Mesozoic paleontological resource which is managed in a manner quite different from other localities. Although adequate materials exist, no comprehensive history of the Dinosaur Quarry has been written. Quarry history is summarized by Chure & McIntosh 1990; McIntosh 1977; and West & Chure 1984. However, these are brief, popular treatments and do not cover such history in detail. Paleontological studies have been primarily morphological and descriptive in nature (Berman & McIntosh 1978; Britt 1987, 1991; Chure 1980, 1981: Chure & Engelmann 1989; Ellinger 1950; Fiorillo 1991a, 1991b; Galton 1977a, 1977b, 1980, 1981a, 1981b, 1982a, 1982b, 1982c, 1983; Galton & Jensen 1973a, 1973b; Galton and Powell 1980; Gilmore 1925a, 1925b, 1932, 1936a; Holland 1915b, 1915c, 1916a, 1924b; McIntosh 1981; McIntosh & Berman 1975; Madsen 1976; Rothschild, 1990; White 1958). Although these studies have focused on dinosaurs, some have examined turtles (Gaffney 1979; Gilmore 1916) and crocodilians (Gilmore 1926, Kay 1951). No scientific studies have been done on the non-vertebrates found in the quarry (such as the abundant unionid bivalves).

Very little is known about Cenozoic (including Quaternary) fossil resources within the monument. Two Cenozoic formations and several types of unconsolidated Quaternary surface materials occur within the monument (see Fig. 1). Although no fossils are known from these formations within the monument, they have produced fossil material (both skeletal and footprints) in exposures near the park. In 1983 several caves were discovered and mapped in the Jones Hole Creek valley by spelunkers from Colorado (Davis 1983, Scoville 1983, Rhinehart 1983). Although no fossil bone was reported to the park by the mappers, caves can serve as traps for Pleistocene fossils and these caves need to be examined for fossils.

C. GEOLOGICAL RESOURCES BASELINE INFORMATION

Dinosaur does not have the hardware necessary to run a UNIX based GIS system. Paleontological Resource Management has a DOS based stand-alone computer capable of running GIS, but doesn't have the additional hardware necessary for a complete GIS station.

Dinosaur does not own any GIS software or hardware.

The only digital data Dinosaur owns is the theme of geologic formations within the park as differentiated by the USGS at a scale of 1:24000.

D. QUATERNARY RESOURCES

In 1989 a limited preliminary study on Quaternary resources was begun on pack rat middens as part of a masters program study through Northern Arizona University. A cursory survey, conducted by Agenbroad and Mead (NAU) in 1992 found fecal matterial from the extinct gian mountain goat and suggested the likelihood of significant, undocumented Quaternary resources are in Dinosaur. Further studies will be required in order to make meaningful evaluations of these suspected resources.

E. GEOGRAPHIC INFORMATION SYSTEM

Because Dinosaur has not utilized GIS technology before, the park presently has little digitized data. Most of the park's resource data is in tabular or paper form which will need to be transferred to stable base overlays before it can be digitized. Fire management estimates that 100% of its present data is on paper maps. Biological resource management estimates that 20% of its data is already digitized, 70% is in tabular and paper map form and 10% is on mylar overlays. Paleontological resource management estimates that 100% of its data is in tabular and paper map form, as does Cultural resource management. Visitor Protection has 100% of its data in tabular form. 100% of the visitor use data is as yet uncollected.

As identified in the DINO GIS Plan (draft), some basic GIS components, such as topographic features, have been digitized (Digital Elevation Model (DEM) data) by other agencies and can be purchased for many areas in Dinosaur. This is data digitized from USGS 7.5 min. quads.

Very little Digital Line Graph (DLG) data is available for Dinosaur. Available data is identified in the DINO draft GIS Plan.

No National Wetlands Inventory (NWI) data is available for

Dinosaur. However, a pending RMRO proposal would split the cost of generating this data from 1:620000 Color Infra Red photography with USFWS through a program coming out of WASO water resources.

Vegetation data is available from WASO in the form of remote sensing images. Also, Landsat images exist for the entire park, though at this time it is not known if this data is available for purchase.

Digitized data is also available from the surrounding BLM districts. This data includes themes such as soils, archeological sites, vegetation, mineral resources etc. BLM data also includes resources on BOREC, state, and some lands within Dinosaur.

III. NATURAL RESOURCES STATUS

A. PROGRAM ADMINISTRATION

Program Administration (the office portion of resource management) is currently the most time-consuming resource management activity at Dinosaur National Monument for both the biological and paleontological branches of the natural resource programs. The project statement for program administration delineates the types of activities associated with (1) administration of in-park programs (2) interagency coordination and (3) planning. The activities appurtenant to program administration must be completed; therefore, due to limited staff size, many field activities are not performed or are performed at less than optimum levels. Program responsibilities for the paleontological section are further complicated by direct responsibility for administering the park's collection management program which covers 30,000 specimens.

Administration of in-park programs includes:

- administering a wide variety of resource management programs such as Quarry fossil management, non-Quarry fossil management, paleontological salvage excavation, geological resources management, fire management, grazing/range management, air quality monitoring, endangered species management, land acquisition, integrated pest management, wildlife management, vegetation management, etc.
- programming and budgeting for resource management operations
- identifying, documenting and evaluating internal threats to monument resources and values.
- identifying research needs; designing and coordinating or supervising research projects, and conducting original paleontological research and publishing results in scientific journals.
- formulating and recommending park policy on natural resource issues.
- providing training for park personnel.
- administering Special Use Permit and Collecting Permit systems.
- supervising permanent and seasonal employees.

Interagency activities include:

- identifying, monitoring and evaluating external threats to monument resources and values.
- reviewing and preparing comments on other agency-organization plans, projects and environmental documents.
- developing and coordinating interagency resource management

programs concerning management of paleontological resources, fire management, endangered species management, air quality monitoring, grazing/range management, wildlife management, etc.
- preparing interagency agreements, memoranda of understanding, etc.
- representing the Superintendent concerning resource management, resource use and natural science research programs with other Federal and State agencies, universities,permittees, research groups, environmental groups and other special interest groups.
- providing liaison with other agencies, organizations and the public concerning resource issues and programs.
- composing and presenting oral and written public statements on resource issues and their interrelationships with other aspects of park management.
- participating in interagency task forces and curriculum development efforts on a wide range of resource issues.
- providing interagency training.
- maintaining extensive contacts with other resource agencies and groups.
- serving as liaison or as a committee member with professional paleontological organizations.
- conducting joint paleontological research with non-Service paleontology professionals and publication of results in scholarly journals.

Planning activities include:

- developing and maintaining resource management plans and related documents such as the Natural Resources Management Plan, Wild and Scenic Rivers Proposal, Wilderness Plan, Fire Management Plan, Land Protection Plan, General Management Plan, Statement for Management, Snowmobile Plan, Backcountry Management Plan and other action plans.
- preparing appropriate environmental documents.
- participating in planning analyses and review of park developments and other in-park planning efforts such as the interpretive prospectus, exhibit and wayside exhibit plans, GIS planning, etc.
- participating in planning of interagency programs at national, State and local levels.

Incumbents in four resource management positions are directly involved in program administration. These include the Paleontologist, Resource Management Specialist, Fire Management Officer and Fire Program Clerk. (Funding for the 2 fire management positions is provided through FIREPRO.) Over 3.0 FTEs of their time is committed to program administration. There remains, in the natural

resource management function, less than 3.0 FTEs which are committed to field and laboratory resource management activities (<2.0 FTEs paleo; <1.0 FTE other natural resources).

Approximately 5.5 FTEs have been available for seasonal employees. The great majority of the funds for seasonal positions are currently provided through FIREPRO (about 4 FTEs), NRPP and other project funds. Very little ONPS base funding is available for seasonal natural resource management positions.

We have projected an immediate need for an additional 4.0 FTEs of permanent staffing and 3.3 FTEs for seasonal positions. An additional 1.0 FTE is needed for GIS operations.

B. STAFFING AND ORGANIZATION

The need for highly developed programs in both the biological realm and the paleontology field results in a unique dilemma when it comes to organization and staffing of a functional natural resource management program at Dinosaur. Most parks have a single staff of resource specialists with a diverse, but intertwined, range of skills which enables the combined staff to deal with the entire range of natural resource concerns. Dinosaur, on the other hand, must maintain dual or parallel natural resource programs: one dealing with paleontological resources and the other with "recent" biological resources. There is no reasonable way to share or exchange personnel between the functions due to vastly different disciplines and positive education requirements.

The paleontological resource management function is currently staffed with a Paleontologist (GS-11) and 2 Fossil Preparators (GS-9). These 3 positions are base funded. Their primary responsibilities include administering paleontological management activities; excavation and management of the Dinosaur Quarry fossils; conducting and publishing in-park research on fossil resources; excavation of vulnerable sites; coordinating research and inventory by non-park investigators of fossil resources; providing technical paleontological information to the general public, the Superintendent and the interpretive staff; laboratory preparation and conservation of fossil specimens; assisting other parks with fossil resources; accessioning, cataloguing, curation and management of a museum collection of some 30,000 specimens; and interagency coordination at federal, State and local levels. Seasonal services are available only as funded by special projects.

The natural resource management function is currently staffed by a Resource Management Specialist (GS-12), a Fire Management Officer (GS-11) and a Fire Program Clerk (GS-05). The FMO and FPC are

funded by FIREPRO and dedicated almost entirely to fire management. The RMS position is base funded. Primary responsibilities of the RMS are administering management activities, directing in-park monitoring and research programs, coordinating natural resource research conducted by cooperators, planning and a great deal of interagency coordination on local and regional levels.

Nearly 4.0 FTEs of seasonal services are funded by FIREPRO. These personnel are dedicated to various aspects of fire management within fire, resource management and visitor protection operations. In 1993 about 1.5 FTEs of seasonal services in resource management were provided by various project funds. Their activities were largely restricted to those associated with the particular project. Less than 0.15 FTE of seasonal services has been available through base funding.

Current levels of staffing and funding are insufficient to meet many biological resource activities mandated by policy and/or law. Efforts to conduct endangered species management and monitoring, management of resource uses such as grazing by domestic livestock, interagency coordination, identification and assessment of threats to park resources, basic resource monitoring and many others simply cannot be effectively implemented at the required levels due to limited staffing and funding.

We have projected an immediate need for 1.0 permanent FTE in paleontological resource management for a GS-07 Curatorial Assistant and 1.5 seasonal FTEs for 3 GS-07 and GS-05 paleo assistants. In the natural resource management function we have identified an immediate need for 3.0 permanent FTEs for a GS-11 biologist (vegetation), a GS-09 biologist (wildlife) and a GS-05 clerk. Over 2.0 FTEs are needed for seasonal services. In addition, a full FTE is needed to administer a park GIS program (a program which will serve all areas of resource management). Planning efforts devoted to GIS are currently being coordinated by the paleontology staff.

The paleontological resource management function (and cultural resource management) currently resides in the Division of Interpretation and is supervised by the Chief of Interpretation. The biological resource management function currently resides in the Division of Resource Management and Visitor Protection and is supervised by the Chief Ranger. This organizational structure has its advantages as well as its disadvantages and is further complicated by the fact that the two activities are geographically based in different locations within the park. Of necessity, the paleo unit is based at the Quarry site in Utah and the biological unit is based at the park Headquarters in Colorado. Creation of a division of science and resource management (with paleo, cultural,

and biological programs) is a topic of ongoing consideration.

C. BIOLOGICAL RESOURCES

1. MAMMALS

a. GENERAL MAMMALIAN FAUNA

Bogan, et al. (1988) identified 65 mammalian species in Dinosaur National Monument based on specimen records and reliable sight records. Included on this list are 3 extirpated species (gray wolf, grizzly bear and bison). Excluded from the list were:

1. feral horses, house mice and domestic animals.
2. black-footed ferret and wolverine, both of which may have occurred here in presettlement times.
3. six species of small mammals which are listed in sight records but not substantiated by specimen records.

Collections made since this report have added 3 species to the known fauna. Thus the known fauna of Dinosaur includes a minimum of 68 native species and perhaps as many as 75 species. This represents a significant increase (50% or more) of in the known mammalian fauna in the last 15 years. Newmark (1986) noted 62 species, including 9 that are not known from the park. Earlier authors (e.g. Armstrong 1972; Lechleitner 1969, Warren 1942 and Cary 1911) suggested 30 to 50 species in the monument.

Bogan et al. (1988) notes that much of the apparent increase in species is due to better sampling methods. The presence of some species now in the monument is certainly due to range expansion. Racoon were not recorded prior to the 1950s. Black-tailed jackrabbits were not documented until the mid-1980s. In other places, the appearance or increase in black-tailed jackrabbits coincided with a decline of white-tailed jackrabbits. This replacement has been associated with certain land use practices such as overgrazing and bringing land into cultivation. Indeed, the first black-tailed jackrabbits collected on the monument were found on range overgrazed by domestic livestock.

Some species have apparently increased in abundance or density as a result of human activities. Both golden-mantled ground squirrels and deer mice are considerably more abundant in campgrounds and other visitor use areas.

Some continued inventory of small mammals is warranted in selected

habitats. Fire effects studies, deer and elk pellet group monitoring, individual species research projects and other activities will yield some information on general species richness and abundance. These not withstanding general inventories should be conducted every 10-15 years to provide updated information on species richness, distribution and abundance.

b. BIGHORN SHEEP

Bighorn sheep once ranged over most of Dinosaur National Monument. The population crashed in the 1930s, largely due to diseases contracted from domestic sheep. Severe competition with domestic livestock contributed to that crash. By the late 1940s, bighorns were entirely extirpated.

In 1952, 32 bighorn were transplanted in the Lodore Canyon area by the Colorado Division of Wildlife. The reintroduced population expanded its range to encompass most of Lodore Canyon. The population reached about 150 animals by the late 1950s, remained stable until the early 1970s and then began to decline rather markedly. Research in the late 1970s estimated the population at about 50 animals and suggested that inbreeding might be the cause of that decline. An increase has been noted in the late 1980s and early 1990s. The population may now be as high as 80-100 animals.

The range occupied by this population has not expanded since 1959 or earlier; adjacent historic habitats have not been occupied. Grazing by domestic livestock and the bighorns' relative lack of pioneering tendencies are probably the primary reasons for the failure to occupy adjacent historic habitats.

In an effort to repopulate other portions of the monument and to counteract potential impacts of inbreeding, an additional 19 bighorns from a different genetic source stock were released near Pool Creek in 1984. That population has become established in the Harpers Corner/Whirlpool Canyon area and is estimated at over 50 animals. From the original release site, bighorns spread across the eastern escarpment Harpers Corner, then into Whirlpool Canyon and, by 1993, some were observed as far downriver as lower Split Mountain Canyon. The majority of the population currently utilizes Whirlpool Canyon. Mixing and interbreeding with the Lodore population is expected (if it has not already occurred).

Lamb:ewe and yearling:ewe ratios suggest that these populations should be increasing. The Lodore population does appear to be growing. Recent observations are not adequate to assess the trend in the Harpers Corner population. Parasites and diseases, accidents, forage nutritional quality, and illegal killing are probably not significant mortality factors. Several other factors,

individually or in combination, may be responsible for limiting population growth. These may include effects of inbreeding (which may be exacerbated by the operation of Flaming Gorge Dam), predation by mountain lions, physiologic stress related to disturbances by whitewater boaters, and effects of livestock on forage and dispersal patterns.

During the fall of 1990, an interdisciplinary assessment team visited the monument as part of a region wide assessment of bighorn sheep populations and their habitats. The team was charged with making preliminary population viability assessments and making recommendations for research and management for several bighorn sheep herds in northwest Colorado and northeast Utah. Pursuant to their report, research was initiated on habitat suitability and utilization, population demographics, growth rates, diseases and parasites, and genetic questions. Most of that research should be available in final reports in 1994. An interagency advisory group was also established to oversee management of bighorn sheep in the Green River corridor (from Flaming Gorge through Split Mountain on the Green River and from Echo Park through Cross Mountain on the Yampa River). Transplants of additional bighorn sheep into the Green River corridor could begin as early as 1994. The ultimate goal is to establish a metapopulation throughout the corridor.

Dinosaur's Management Objectives direct the maintenance of a viable population of bighorn sheep in the monument. The monument's goal is to establish bighorns throughout their former range in the monument. Prescribed fire may be used to remove sagebrush and induce pioneering by bighorns into former ranges. Additional transplants, with due regard to genetic considerations, will be necessary to establish herds in areas more remote from present populations.

c. ELK

Prior to the mid-1970s, few elk were observed in Dinosaur National Monument. Population estimates for 1974 and 1975 were 20 and 40 animals respectively. These were primarily on Douglas Mountain. From 1975 through 1981, progressively more elk were observed in the monument. This increase was attributed to three factors: reproduction in the "resident" population, removal of feral horses from Douglas Mountain, and immigration from nearby areas subject to hunting. By the early 1980s, a significant (but unknown) number of elk utilized summer ranges in the monument on Wild Mountain, Douglas Mountain and Blue Mountain. A few elk also utilized the southern lower elevations of Douglas Mountain and the eastern half of the Yampa Bench as winter range.

In the early 1980s, two programs were instituted which have

contributed to dramatic population increases within the park. First, Dinosaur initiated in 1981 a complex fire management program involving prescribed burning and prescribed natural fires. During the past 10 years, approximately 12,000 acres within the park have burned. A similar acreage has burned on adjacent BLM and private lands. As a result of this burning, large areas have been converted from sagebrush and pinyon-juniper types to grassland. Secondly, the Colorado Division of Wildlife began (in 1982) special limited bull elk seasons adjacent to the monument on Wild Mountain, Douglas Mountain and Blue Mountain. By the late 1980s, large numbers of cow elk were being harvested in the same areas in an effort to reduce herd levels. Rather marked annual movements of elk into the park have been observed in response to the opening of hunting seasons.

Partially as a result of these two factors, elk are now distributed widely throughout the park. Some areas are used seasonally; other areas are used near year-around. Population levels within the park may reach or exceed 1,000 animals during some times of the year.

As elk populations continue to increase and as elk continue to move into the monument in response to hunting pressure, significant increases in illegal hunting have been observed. Nearly 100 miles of Dinosaur's boundary (in Colorado alone) are adjacent to areas which are open to elk hunting at the same time. Existing manpower and monies provide for only very limited patrols during elk seasons.

Elk pellet group transects were established throughout much of the park in 1984 to monitor trends in elk use. Several transects were located for use in fire effects studies.

d. MULE DEER

Dinosaur provides both summer and winter range for mule deer. Summer ranges are primarily confined to areas of higher elevation (7,000+ ft.) near the monument boundaries on Blue Mountain, Douglas Mountain, Wild Mountain and Split Mountain. There are five distinct winter ranges in the monument at elevations of 4,700 ft. to about 6,200 ft. The west end of the Yampa Bench and Island Park are relatively large critical winter ranges. Deerlodge Park, the Gates of Lodore and the south side of Split Mountain are smaller winter ranges. Franzen (1968) documented that most of the deer utilizing Dinosaur winter ranges migrate from outside the park. There are a few small resident herds in the river canyons and bench areas.

Population levels on winter ranges have varied widely depending on

overall deer populations and the severity of winters. Franzen (1968) reported maximum numbers of approximately 2,500 deer on the Yampa Bench range and approximately 1,000 deer on the Island Park range (both figures from the late 1940s). Average populations on these two areas in recent years were less than 500 and 300 deer respectively.

Franzen (1968) reported pre-hunting season buck:doe ratios on Blue Mountain and Harpers Corner of 66:100 in 1966 and 63:100 in 1967. The 1966 post-season ratio was 46 bucks:100 does. Fawn:doe ratios were 91:100 in 1966 and 95:100 in 1967.

Mule deer age and sex rations, based on trend counts conducted by the NPS and Colorado Division of Wildlife, have changed significantly during the past 20 years. Pre-hunting season buck:doe ratios from 1974 through 1990 ranged from 6.3:100 to 27.8:100 (median about 16:100). Post-season ratios ranged from 2.4:100 to 10.6:100 (median about 5:100). Fawn:doe ratios for those years ranged from 50.0:100 to 81.3:100 (median about 60-65:100). These figures are from Blue Mountain; population ratios in and adjacent to other parts of the park are similar. The trend count routes, counting techniques and times of year were comparable to those of Franzen.

Severe winters in the early 1970s and heavy hunting pressures probably caused the initial population declines in buck:doe ratios. Continued heavy hunting pressure probably contributes to the extended depression in buck:doe ratios. The Colorado Division of Wildlife and Colorado State University are currently conducting research on mortality factors in mule deer populations (Blue Mountain is a control area). Initial findings seem to show compensatory mortality within the test populations. The Division of Wildlife has also limited harvest in Big Game Units adjacent to the monument since 1992. Increases in buck:doe ratios are already evident.

The National Park Service management of mule deer populations in Dinosaur National Monument has been limited to monitoring and protection actions. Monitoring actions have included deer counts along prescribed routes, browse utilization studies, and pellet group transects. Data and associated recommendations are provided to the Colorado Division of Wildlife and Utah Division of Wildlife Resources for consideration in setting deer seasons and allowable harvest. Protection actions have included hunting and poaching patrols and patrols to prevent or minimize trespass grazing on winter ranges.

For the past several years, manpower and monies have been insuffi-

cient to complete any of the monitoring actions except for a few deer counts. For the same reasons, hunting and poaching patrols have been reduced by approximately 75 per cent since the mid-1970s. Grazing by domestic livestock on most of the critical Yampa Bench winter range was terminated in 1976; grazing on the other winter ranges was largely terminated in 1985.

e. PRONGHORN ANTELOPE

Pronghorn antelope had been extirpated from Dinosaur National Monument. In January of 1983, the Colorado Division of Wildlife and Dinosaur National Monument cooperatively released 86 pronghorn antelope on the west end of the Yampa Bench (near the Success Burn). All animals were ear-tagged. During the spring of 1983 most of the released antelope moved up through Hells Canyon and/or over the Blue Mountain rim. Ear-tagged antelope were observed on the Yampa Plateau (Blue Mountain) during the summer of 1983 from Stuntz Ridge east to Disappointment Draw. By the winter of 1983-84, many of the tagged animals were located on low elevation winter ranges along U.S. Highway 40 from Massadona to Elk Springs.

During the severe winter of 1983-84, hundreds of pronghorn antelope migrated into various portions of the monument from the north (many from Wyoming). Several hundred animals were forced into Lodore Canyon; by mid-summer all of these antelope had died. Most of the antelope which appeared in other parts either died or left the area by early summer.

Small numbers of pronghorn antelope are occasionally observed within the park on the Yampa Bench. Several factors, including predation, may be effective in keeping these numbers very low (total 10-20 animals). A rather substantial population now utilizes the Yampa Plateau along Moffat County 16. These are likely derived from the 1984 release on the Yampa Bench.

Management actions for pronghorn antelope are limited to recording of incidental observations within the monument.

f. RIVER OTTERS

River otters were endemic to the Dinosaur National Monument area but are believed to have been extirpated. Occasional sightings of river otters have been reported in Jones Hole Creek and in the Green River below Echo Park during the past 20 years. The authenticity of these reports has not been established. Although a few of the reports sound plausible, most observations were probably of a closely related species such as mink.

The Colorado Wildlife Commission, in 1975, designated the river

otter as endangered in the State of Colorado. The Colorado Division of Wildlife (CDOW) is engaged in a river otter restoration program on selected rivers in Colorado. The Green and Yampa Rivers in Dinosaur National Monument are among the potential release sites for this program. No otters have been released to date in Colorado.

The Utah Division of Wildlife initiated an otter reintroduction effort in 1989. The plan proposes eventual re-establishment of otter populations in the Green River from Flaming Gorge Dam to its confluence with the Colorado River. About 20 otters will be released at each of several identified release sites.

River otters were released in the Green River below Flaming Gorge Dam in 1989 and 1990. Some of these animals have ventured, at least temporarily, downstream into Lodore Canyon, Whirlpool Canyon, Island Park and the lower Yampa Canyon. Although 2 or 3 of the animals remained in Lodore Canyon, most returned to near the release site.

About 20 river otters were released in Island Park began in 1991 and 1992. Monitoring by radio telemetry documented that the otters spread throughout the Green River in the monument. Some have been observed as far upstream on the Yampa River as Deerlodge Park. Several litters have been observed. Based on analysis of scat, the primary diet items have been channel catfish and common carp. This reintroduction seems to have been a complete success. Together with the releases both upriver and down river, otter populations should be secure for the foreseeable future.

NPS management actions will include cooperation with Utah Division of Wildlife Resources in monitoring the reintroduced populations.

g. LARGE PREDATORS

Large mammalian predators within Dinosaur include coyote, bobcat, mountain lion and black bear. Relatively little is known about their population status or habitat use.

Coyotes seem to be widespread in the monument. Lions are also rather widespread with indications that ranges are being expanded into lower elevation areas. Sightings of bobcats are largely limited to lower elevations (under about 6,000 feet). Black bears have been seen on occasion for several years. Reports of sightings are most common within the river canyons, the area of highest backcountry use. Other sightings have occurred at scattered locations in upland areas. Bear sightings were most frequent during periods of high populations of Mormon crickets.

Influences on populations of these mammals are largely unknown. There are been some indications of efforts to trap coyotes and bobcats near the boundary and on private inholdings. There remain persistent rumors of lion hunters following mountain lions into the park. Animal Damage Control (APHIS) programs are conducted very near the park on lands utilized by domestic livestock.

Wolves, wolverine and grizzly bear have been extirpated from the monument and regional lands. There is one recent specimen record of a wolverine killed near the monument and we have received several reports of sightings on lands adjacent to the monument.

h. BATS

In recent inventory efforts, 14 species of bats have been collected in the monument. This represents in increase of 6 species over those known in 1980. Two species, the spotted bat (Euderma maculatum) and fringed myotis (Myotis thysanondes), are apparently quite rare. Spotted bats have been collected or otherwise recorded in several locations but their numbers are apparently very low. The fringed myotis has been collected from only one or two localities.

Although little is known of bats in the monument, the variety of species captured and the range of habitats potentially available in Dinosaur suggest that this area may support one of the most diverse bat faunas in Colorado. Impacts of visitor use and land management practices to small mammals, particularly bats, are often overlooked in park management decisions since so little is known of species diversity, species abundance and vulnerability of habitats. Some species may provide important indicators of environmental conditions in the monument.

Some of their habitats (e.g. roosts, hibernacula) may be limited and quite vulnerable to modification by visitor use or changes in land use. At least 2 roost areas or hibernacula were identified in 1991. One of these is very vulnerable to visitor disturbance.

i. PRAIRIE DOGS/BLACK FOOTED FERRETS

Fairly extensive white-tailed prairie dog colonies occur near the Quarry area. Although numbers and areas occupied were drastically reduced in the mid-1980s due apparently to a natural epizootic, populations have often occupied an area of up to 1,000 acres.

Large colonies exist near U.S. Highway 40; some of those extend onto park lands near monument headquarters. Small colonies occur on East Cactus Flat and on the Success burn. Individual prairie dogs are occasionally reported in other areas of the park.

Some investigators (e.g. Newmark 1986) suggest that black-footed ferrets may have occupied lands now incorporated into Dinosaur National Monument. Although no specimen records exist from the park or adjacent lands, there have been many reports of sightings along U.S. Highway near monument headquarters.

Northwestern Colorado and northeastern Utah are included in plans to reintroduce black-footed ferrets. The proposed reintroduction site in Colorado is near the Wyoming border; the secondary site is near the monument along U.S. Hwy 40. The proposed Utah reintroduction site is in Coyote Basin, south of the monument. All three sites are proposed for 10(j) designation (experimental, non-essential populations). If these reintroduction plans are fully implemented, black-footed ferrets may eventually occupy park lands.

j. FERAL HORSES

Nearly 700 feral horses were removed from Dinosaur national Monument and adjacent BLM lands on Douglas Mountain from 1977 through 1979. Both agencies agreed to license no range use for domestic horses after the interagency trapping effort. Any horses ranging on the area are to be regarded as trespass or feral animals and removed as expeditiously as possible.

In the 1960s and 1970s (and earlier) feral horses roamed freely over contiguous NPS and BLM lands on Douglas Mountain. Prior to passage of Wild Horse and Burro Act (P.L. 92-195) in 1971, roundups conducted by ranchers and/or the BLM held the population to tolerable levels. After passage of the Act, ranchers were prohibited from capturing these horses. They were also prohibited from rounding up private horses (ranged pursuant to grazing permits) which utilized the same ranges as did the feral horses. Horse numbers on Douglas Mountain were estimated at 150 animals in 1971, 350 animals in 1974, and 450 to 500 animals in 1976.

Pursuant to an interagency management plan, trapping operations were conducted from July 1977 through November 1977 and from August 1978 through January 1979. No trapping occurred during other months to avoid undue mortality to pregnant mares and young foals. Captured animals were placed in BLM's Adopt-a-Horse program unless they could be claimed by local ranchers under Colorado estray laws. A total of 673 horses were captured during the roundup. Table 1 shows the distribution of capture and disposition of these horses.

Table 1. Distribution and disposition of horses removed from Douglas Mountain, 1977 -1979.

	1977	1978-79	TOTAL
Captured	508	165	673
Claimed	147	21	168
Adopt-a-Horse	361	144	505

Range surveys conducted by the BLM in 1974 and 1976 showed significant range deterioration and downward trends in condition. Many ranchers on Douglas Mountain voluntarily reduced their authorized grazing by 30 to 50 per cent because of a lack of available forage.

Subsequent to the 1976 range surveys, reductions in total use on federal range were imposed on Douglas Mountain permittees in 1978. Improvement in range conditions was quite evident as early as 1978 over large portions of Douglas Mountain. Range conditions have continued to improve through the present time.

Significant diet overlap exists among domestic cattle, horses and elk (Olson and Hansen 1977, Hansen et al. 1977). It is likely that significant diet overlap also exists between horses and bighorn sheep. With removal of feral horses, reductions in livestock use, and subsequent improvements in range conditions, elk numbers and areas of use have greatly expanded on Douglas Mountain. Bighorn sheep have not expanded their range into areas formerly utilized by feral horses but other factors also constrain sheep numbers and ranges.

Limited monitoring for horses has continued incidental to other protection and resource management activities. Any horses found on Douglas Mountain or other areas will be removed in accordance with 36 CFR 5.11 and other appropriate trespass procedures. Unclaimed animals may be removed by any appropriate means.

Please refer to the 1983 Resource Management Plan for greater detail concerning feral horses and the 1970-1977 removal program.

k. STRIPED SKUNKS

Densities of striped skunks (Mephitus mephitus) have occasionally reached unnatural levels in certain campgrounds in Dinosaur National Monument due primarily to the concentration of visitors and their attendant food scraps. Frequent complaints from visitors, particularly physicians and veterinarians, concerning depredations by skunks and the potential for rabies outbreaks have led to periodic reductions in skunk densities.

Wade-Smith and Verts (1982), summarizing from other authors, provide the following information on striped skunks:

(a) skunk densities in most occupied habitats range from 1.8-4.8/sq. km (1 skunk per 8.4-22.7 acres):
(b) movements of adults are typically within a radius of 0.8 km (0.5 miles); 90 per cent of movements of juveniles in summer and fall are less than 640 meters (0.4 miles);
(c) home ranges are often linear and average:
    511.5 ha (1264 acres) for adult males
    378.0 ha (934 acres) for adult females
    283.7 ha (701 acres) for juvenile males
    234.3 ha (579 acres) for juvenile females
(d) litter size averages 5.8 to 7.8 young
(e) annual mortality averages from 50 to 71 per cent, most of it occurring late fall and winter; and
(f) the incidence of rabies in skunks exceeds that for any other domestic or wild species.

Efforts have been made to educate visitors about ways to make their camps less attractive to skunks and thus reduce human-skunk interactions. If monitoring documents that skunk densities significantly exceed natural population levels in visitor use areas, reductions may be considered.

2. BIRDS

a. GENERAL AVIAN FAUNA

Over 200 species (217 documented; an additional 20-30 species expected) are reported in Dinosaur's bird checklist. The checklist represents at best a partial catalog of birds using monument lands. There has been no systematic inventory of bird species within the monument. A systematic inventory of avian fauna should be conducted in the park. Incidental observations might then be used to supplement the inventory.

Unlike mammal, herptile, insect and aquatic baselines, virtually no specimen records exist to substantiate the bird checklist. Some consideration should be given to establishing a specimen record of those species which are less common, less easily identified or more readily confused with other species. Such specimen records would also be useful for taxonomic and biogeographic studies.

Several species have been introduced by human activities. These include the house sparrow, starling, chukar and ring-necked pheasant. These generally do not present significant ecological or economic problems. There is, however, some information which

suggests coccidiosis may be transferred from chukar to bighorn sheep. If this is documented, chukar may then be regarded as an ecological problem.

Those species which are of greatest management interest include peregrine falcon and bald eagle. Prairie falcons, northern goshawks, burrowing owls, Canada geese, and ferruginous hawks are of concern because of questions about population status or unusual habitat utilization in the monument. Historic records suggest the presence of Mexican spotted owls near, if not in, lands incorporated in the monument. Peregrines have been the focus of a major recovery effort. We expect that considerable effort will be expended in the immediate future to survey for spotted owls.

b. PEREGRINE FALCON

The American peregrine falcon (Falco peregrinus anatum) is endemic to Dinosaur National Monument. Most of the monument provides suitable habitat for peregrines. High sheer cliffs, abundant throughout the area, are of particular importance as eyrie sites. Perennial waters and large expanses of intermixed vegetative communities provide habitats for a diverse prey base.

Recovery activities began in Dinosaur National Monument in 1976. Over the years, recovery activities have included eyrie searches, eyrie protection and monitoring, recycling, augmentation, prey studies (availability and pesticide loading), and hack site operation. All recovery activities have been consistent with the approved (1984) American Peregrine Falcon Recovery Plan (Rocky Mountain/Southwest). All recovery activities are coordinated with cooperating federal and State agencies.

Only 1 eyrie was known in Dinosaur in 1976; a second was discovered in 1977. These constituted the northernmost remnant of breeding populations in the Rocky Mountain region. By 1990, 8 sites within the monument were occupied by adult pairs of peregrines. Another occupied site occurs just outside the monument. In 1992 and 1993 respectively, 13 and 11 sites were occupied by adult pairs. Based on present knowledge of territory size, habitat saturation may occur when 16-20 sites are occupied. Summaries of populations and production in the monument since 1977 are available in annual reports in park and Regional Office files.

DDE levels in prey species collected in and near Dinosaur (1978-1980, 1989) have remained sufficiently high to cause significant eggshell thinning in peregrine eggs. Shell thinning in eggs from the monument continues to be of concern; thinning in individual eggs often exceeds the critical threshold of 18%.

Management Objectives for Dinosaur call for the protection and recovery of endangered species in the monument.

Table 2. Peregrine falcon population and production summary, Dinosaur National Monument, 1977-1993

	1977	1978	1979	1980	1981	1982	1983	1984
Occupied Sites	2	2	2	2	2	2	2	2
Adult Pairs	2	2	2	1	2	1	1	2
Mixed Pairs							1	
Lone Birds				1		1		
Breeding Pairs	2	2	2	1	2	1	1	2
Productive Eyries	1	1	2	1	2	1	1	1
Recycled Sites			1					
Fostered Sites	1	1	2	1	2	1	1	1
Young Fledged								
Fostered	0	3	7	4	6	0	4	4
Natural	2	0	0	0	0	0	0	3
Total Fledged	2	3	7	4	6	0	4	7
Young Banded	2	3	7	4	6	0	4	7
Shells Collected	?	Y	Y	Y	Y	Y	Y	Y
# Eyries	2	2	2	1	2	1	1	1
Hack Sites (#)	0	0	0	1	0	1	1	2
Young Fledged	0	0	0	0	0	4	4	8

Table 2. continued.

	1985	1986	1987	1988	1989	1990	1991	1992	1993
Occupied Sites	2	3	5	6	9	8	10	13	11
Adult Pairs	2	2	3	3	7	8	10	13	11
Mixed Pairs	0	1	2	2	1	0	0	0	0
Lone Birds	0	0	0	1	1	0	0	0	0
Breeding Pairs	2	2	3	3	5	8	10	13	9
Productive Eyries	2	2	3	3	5	6	8	8	8
Recycled Sites	0	1	0	2	2	2	0	0	0
Fostered Sites	2	1	3	3	1	0	0	0	0
Young Fledged									
Fostered	8	2	9	9	3	0	0	0	0
Natural	0	3	0	0	7	11	15	13	17
Total Fledged	8	5	9	9	10	11	15	13	17
Young Banded	8	2	10	12	6	2	12	0	3
Shells Collected	Y	Y	Y	Y	Y	Y	Y	N	Y
# Eyries	2	1	3	3	2	3	4	0	1
Hack Sites (#)	0	1	1	1	0	0	0	0	0
Young Fledged	0	1	4	3	0	0	0	0	0

c. BALD EAGLE

Dinosaur National Monument provides important winter habitat for bald eagles (Haliaeetus leucocephalus). Concentrations of bald eagles are commonly observed in cottonwood bottoms along both the Green and Yampa Rivers from December through March. The primary concentration areas include Deerlodge Park, Gates of Lodore, Island Park and below Split Mountain. The Deerlodge and Lodore sites are parts of larger concentration areas comprised of NPS and adjacent lands. It is not uncommon to see 10 to 20 bald eagles in the Deerlodge and Island Park areas. Smaller numbers are commonly observed at Lodore, below Split Mountain and along the entire lengths of both rivers in the monument.

Disturbance of wintering bald eagles does not appear to be a major problem. Most disturbances occur in Island Park (associated with activities on nonfederal lands) and below Split Mountain (associated with campground activities).

A potential habitat problem exists along the Green River. Since the closure of Flaming Gorge Dam, there appears to have been a significant reduction in cottonwood regeneration. Preferred roosting sites are large mature cottonwoods. It is conceivable that, over time, these cottonwoods would not be replaced naturally and the habitats would eventually become less desirable for wintering bald eagles.

Park management activities concerning bald eagles have been limited to protection of cottonwood groves (roosting areas) and participation in the annual Mid-winter Bald Eagle Survey. If conditions warrant, concentration areas could be seasonally closed to human entry. Status of cottonwood regeneration should be determined in concentration areas. Regeneration may be inadequate due to Flaming Gorge Dam which prevents periodic flooding. If regeneration is not sufficient to provide replacements for old mature trees, a cottonwood planting program could be initiated. If such a program is implemented, plantings in various areas should be designed to result in near even-aged stands to approximate natural conditions.

d. MEXICAN SPOTTED OWL

Historic records suggest that the Mexican spotted owls (Strix occidentalis lucida) occurred in or near the monument. Habitats available in Dinosaur appear to be similar to those utilized elsewhere on the Colorado Plateau.

No systematic surveys have been conducted in the monument. Some cursory surveys have been attempted since 1991, but the number of site visits and duration of listening are short of that recommended

in survey protocols. Nonetheless, in at least one location, calls were heard which sounded like those of a spotted owl.

Park management activities associated with the Mexican spotted owl will likely include surveys for occupancy, habitat characterization, and protection of known and/or potentially suitable habitat.

e. CANADA GEESE

Canada geese (Branta canadensis) utilize Dinosaur's river canyons as nesting and wintering habitats. Up to 50 pairs of nesting geese are found along the Green River with most pairs located in Lodore Canyon and Island Park. Perhaps half as many nest along the Yampa River. Nesting densities along the Green River are higher than along the Yampa, perhaps because more islands are exposed throughout the spring on the Green.

Although most of the geese nest on islands, a unique situation exists in Lodore Canyon. With relatively few suitable island sites available, geese nest on ledges in the canyon walls at heights of up to 30 feet above river level. Observations of clutch size, brood size and predation indicate that cliff nesters are as successful or more successful than island nesters. The reproductive success of island nesters is strongly influenced by flow releases from Flaming Gorge Dam. Higher than normal flows inundate some nests while very low flows cause increases in losses to mammalian predators as islands become peninsulas. Nest predation by golden eagles also appears higher among island nests than cliff nests.

Since the closure of Flaming Gorge Dam in 1962, the Green River in Dinosaur seldom freezes over. The Yampa still freezes during most winters. Wintering geese on the Green River number in the hundreds. Significant numbers of geese have not been observed along the Yampa during winter.

The Browns Park National Wildlife Refuge, situated just upstream from the monument on the Green River, is managed for Canada geese production. Birds usually do not winter in the refuge; it appears that they move into Lodore Canyon when the Green River freezes over in Browns Park. It is unknown if the wintering population is comprised mainly of resident birds or of migrants from other areas.

Goose biologists have stated that geese can probably tolerate one flushing from the nest (eggs left uncovered and more vulnerable to predation or mortality due to weather conditions) per day without serious impacts to reproductive success. Increased disturbances to nesting geese by boaters could result in reduced reproductive success and eventual displacement of nesting geese.

Management of Canada geese in Dinosaur by the NPS has been quite limited. River travel on the Green is restricted to one launch per day prior to May 10 to minimize disturbances to incubating and brooding geese. The Utah Division of Wildlife Resources and Colorado Division of Wildlife are conducting a long-term study of Canada geese in northeastern Utah and northwestern Colorado. Primary components of the study are examinations of breeding success and wintering populations. Monument staff participate in the now infrequent spring nesting surveys of the monument.

3. REPTILES AND AMPHIBIANS

The status of reptiles and amphibians within Dinosaur is largely unknown. A baseline inventory was initiated in 1991 in cooperation with the National Ecology Research Center. The final report of that inventory is expected in 1994.

4. FISH AND OTHER AQUATIC ORGANISMS

a. GENERAL FISHERY RESOURCES

A total of 26 species representing 9 families have been collected in the Green and Yampa Rivers during recent fishery investigations. Of these, 9 were native (6 endemic to the Colorado River Basin) and 17 were non-native species. Four of the endemic species are endangered: Colorado squawfish, bonytail chub, humpback chub and razorback sucker. Flannelmouth sucker and roundtail chub are candidate species. Flannelmouth sucker, bluehead sucker and speckled dace are the most abundant native species. The most common non-native fishes include red shiner, channel catfish and carp. The Yampa supports more species than does the Green River above their confluence.

Several species are of particular management and research interest. The endangered fish are subjects of long-term research and monitoring. Brown trout, rainbow trout and cutthroat trout have all been introduced to the river system. These are of interest to recreational anglers and are found most often in Lodore Canyon and Jones Hole Creek. Certain other non-native species are of particular interest because of their potential or demonstrated impact on endangered fishes through predation or competition for selected habitats. These include channel catfish, northern pike, green sunfish, fathead minnow, carp and red shiner. Both channel catfish and northern pike are important predators on certain life stages of the endangered species. Red shiner and fathead minnow are important competitors in Colorado squawfish nursery areas. Ongoing studies are examining the magnitude of impact on endangered fishes.

b. ENDANGERED FISH

The Colorado squawfish, humpback chub bonytail chub and razorback sucker are listed as endangered pursuant to the Endangered Species Act. These four species are endemic to the Colorado River System. At present their ranges are extremely restricted and population numbers have been severely reduced. The proximate cause of their collective decline is the construction of mainstream dams resulting in (1) flow modifications (timing, volume, water chemistry), (2) siltation and chemical pollution, (3) introduction of and predation by exotic species, (4) loss or modification of habitats and (5) loss of migratory routes. The respective Recovery Plans provide detail on present distribution and abundance, life history information, reasons for decline, etc.

The interagency Recovery Implementation Program proposes to recovery the endangered fishes within a 15-year period (1988-2003) while still allowing continued water development. This multi-agency entity funds most of the ongoing research related to the endangered fish. It has also developed several publications and plans which provide additional information on the fish and their management. The National Park Service has been excluded from participating formally with this group.

Critical habitat has been proposed for all four species. The river systems within Dinosaur have been identified in their entirety as critical habitat for all 4 species.

The Yampa River, with its near-natural flows, is as the primary factor sustaining the continued existence of these species in the Upper Colorado River Basin. Loss of natural flows may result in extinction of these species in the wild.

Pursuant to a "jeopardy" opinion from Section 7 consultation, Flaming Gorge, on the Green River, is being "reoperated" to provide flows more amenable to endangered fish. Experimental flows are being released from 1992 through 1996. Flow patterns will be more firmly established by a revised Section 7 opinion due in 1997 (see discussion under Water Resources for additional information).

COLORADO SQUAWFISH

The Yampa River in Dinosaur provides adult habitat, some nursery habitat and the most important of only two known spawning areas for Colorado squawfish. Most of the Upper Basin production occurs around River Mile (RM) 16.5; swim-up fry then drift to nursery areas in the Green River (Island Park to Ouray). Spawning migrations of up to 200 miles to and from the RM 16.5 have been documented by tracking radio-tagged fish.

A summary FWS report (Tyus and Karp 1989) concludes that any decreases in river flow and/or sediment transport would result in adverse impacts to Colorado squawfish spawning habitats, spawning success, young-of-the-year (YOY) survival, and nursery habitats. The report notes that high spring flows are important in squawfish migration patterns and recommends no flow reductions during runoff. It further notes that significant increases in base flows during the summer could adversely affect recruitment of YOY in the Green River Basin.

The report notes that sediment from the Little Snake is critical for maintaining natural geomorphological conditions in the Yampa and upper Green Rivers. Any decrease in sediment input could have significant adverse impacts on squawfish spawning areas.

Furthermore, competition and predation by non-native fishes depress the endangered fish populations. Flow modifications have been implicated as the factors which have altered habitats and made them more amenable to non-native fishes. Therefore, additional flow modifications could further exacerbate existing problems with non-native fishes.

The U.S. Fish and Wildlife Service has issued a "jeopardy" opinion of the current operation of Flaming Gorge Dam. Reasonable and prudent alternatives recommended by FWS for avoiding jeopardy include reoperation of the dam to provide flow releases specified by volume and timing. Experiments flows will be released from 1992-1996.

In summary, the report strongly recommends that no reductions in flow and sediment transport can be tolerated in the Yampa River.

Research is continuing on many aspects of Colorado squawfish demography and ecology. Of great interest is research on olfactory cues to spawning. The great migration distances (100 and more miles) to spawning bars and the extreme fidelity to spawning locations suggests some olfactory cue. Initial laboratory studies indicate that Colorado squawfish are extremely sensitive to various chemicals in the water.

A draft population viability analysis indicates that Colorado squawfish populations are probably far more secure than those of the other 3 endangered fishes.

HUMPBACK CHUB

Studies in the late 1980s indicated that the humpback chub population in the Yampa River (RM 18) might be the only genetically pure population in the Upper Basin. Other populations in the Upper

Basin have exhibited significant hybridization with the more common roundtail chub, possibly due to altered river flows in those occupied reaches. Genetic research began in 1991 to assessing the genetic integrity of the Yampa population. The presence of morphological intergrades (between humpback and roundtail chubs) observed in other research (which began in 1993), suggested that some hybridization with roundtail chubs may now be occurring. This population is important not only in and of itself, but also for brood stock for transplants or reintroduction throughout the Upper Basin.

The FWS report notes that humpback chubs spawn at peak runoff and that high spring flows are critical for successful spawning. Tyus and Karp (1989) recommend that no reductions be allowed in spring flows.

BONYTAIL CHUB

The bonytail chub may be extirpated from Dinosaur. During the past 5 to 6 years only a few (1 to 2 per year) phenotypic bonytails have been captured by researchers; most of these have been from the Green River in Gray and Desolation Canyons. The last site of common captures, however, is Island Park in Dinosaur. Releases of captive-produced adult bonytails were made during 1988 and 1989 in the Island Park area for the purpose of studying movements and habitat selection.

The bonytail chub, of all the endangered Colorado River fishes, responded most dramatically to mainstream impoundments; it is nearly extirpated from riverine habitats throughout its former range. The Yampa River, with its flows maintaining some semblance of near-natural conditions throughout the Green River Sub-basin, is critical for any chance of survival and recovery of the species in riverine habitats.

RAZORBACK SUCKER

Razorback suckers are concentrated in the Green River from its confluence with the Yampa River (Echo Park) to Jensen, Utah. Individuals of this species may live to 30-50 years. Although a few fish have been captured in the Colorado River, this population in the Green River is the only remaining wild riverine population of razorback suckers. Analysis of tag and recapture data collected since the early 1980s indicated that only about 1,000 adult razorback suckers remained in the Upper Basin by the late 1980s. Virtually all of the fish collected were older than Flaming Gorge Dam. Spawning and young-of-the-year (YOY) fish were documented annually during these studies but no juvenile fish were captured.

The U.S. Fish and Wildlife Service (FWS), in the late 1980s, captured several hundred razorback fry and placed them in "grow out" ponds on the Ouray refuge; those fry responded well to the absence of predators.

Recent studies have observed some limited recruitment from the 1984 cohort. This cohort was spawned in a year with very high flows and significant overbank flooding (which probably provided the first good nursery habitat in over 30 years). The population of adult fish, however, was reduced to only 400-600 fish.

The suspected cause of the nearly complete loss of all YOY cohorts is habitat loss and predation by non-native fish, species whose existence in the Green is made possible by altered flow characteristics due to Flaming Gorge. Current hypotheses suggest that extended overbank flooding near spawning areas is necessary for the survival and growth of larval razorback suckers. Zooplankton production is orders of magnitude greater in flooded bottomlands than in the most productive riverine habitats. Such zooplankton provides both forage for larval razorbacks and a buffer from predation by non-native fishes. Current studies, reoperation of Flaming Gorge Dam, and purchase or leasing of selected bottomlands will all contribute to a better understanding of the role of flooded bottomlands in recruitment of razorback suckers.

c. AQUATIC VERTEBRATES

About 100 taxa of aquatic insects were identified in the Yampa River by Carlson et al. (1979). Mayflies were the most abundant order. Caddisflies were the next most abundant order. Stoneflies, true flies and beetles were other important orders, and Chironomidae (Diptera) was the most common family. This research also identified several non-insect macroinvertebrates, of which Oligochaete worms and Hydracarina were most common.

Pearson (1967) identified about 70 invertebrate forms which were collected in the Green both before and after closure of Flaming Gorge Dam. He notes that several taxa reported prior to September, 1962 (mostly mayflies and stoneflies), were not reported after the dam closed. At least 10 "new" invertebrate forms were collected in 1963-1965, most of which were more common to cool mountain tributaries. In addition to these forms, Pearson (1967) also found 11 different types of Baetis (mayfly) nymphs not previously recorded. Perhaps most importantly, Pearson (1967) concluded (1) that species composition above Echo Park changed significantly after Flaming Gorge Dam closed, (2) species composition below Echo Park did not differ significantly from pre-impoundment studies, and (3) species diversity increased with increasing distance downstream from the dam.

No research or monitoring has been conducted in aquatic invertebrates since the 1970s. The Green River, as regulated by Flaming Gorge Dam, has been essentially unchanged since 1962 except for some warming after installation of penstock modifications in 1978. The Green may sustain significant changes to habitats for macroinvertebrates if releases are modified in response to the needs of endangered fishes. It would therefore be appropriate to re-inventory aquatic macroinvertebrates in the near future.

5. INSECTS

a. GENERAL INSECT FAUNA

Development of an insect baseline inventory is underway through Colorado State University. Dr. Boris Kondratieff and others have made several collecting trips to the monument. Monument staff have also assisted by operating light traps and malaise traps in several locations and habitats within the park. Dr. Kondratieff has been loaned virtually the existing collection from the park to complete or verify identifications.

Some 950 species have been identified including at least 50 species new to science. Researchers suggest that another 500 species of insects occur in the monument. Included in the insects collected since 1990 are several new State, County and monument records. Some research had been conducted to identify the pollinators of Spiranthes diluvalis. The only insects of significant management interest at this time are Mormon crickets.

Other arthropods, including soil insects are largely uninventoried. Researchers esitmate that approximately 25% of the monument's arthropod fauna has been verified by specimen records. There is no immediate prospect for identifying the full range of arthropods in the monument.

b. MORMON CRICKETS

The Mormon cricket (Anabrus simplex), a wingless grasshopper endemic to the area, is an irregularly recurring pest throughout much of the intermountain West. Populations may exist at low, relatively insignificant levels for several years in an area. Then given a period of favorable years, they may increase exponentially. At high population levels, Mormon crickets become gregarious and form bands that begin to migrate. These migrating bands may move 25 to 50 miles in a season.

In their food habits, these omnivorous insects show a marked preference for succulent plants and inflorescences but will eat

almost any green plant. Highest utilization typically occurs on shrubs and forbs such as sagebrush, rabbitbrush, arrowleaf balsamroot, death camas, locoweed and groundsel. Utilization of range grasses is disproportionately low compared to their availability. Recent research (MacVean 1987) indicates that, absent severely deteriorated range conditions, Mormon crickets have a negligible impact on forage production even in "epidemic" numbers. Mormon crickets may be of greater significance on rangelands as "ecological cleansing agents" than as agricultural pests. Measurable economic impact by Mormon crickets on cultivated crops has been well documented. There are no cultivated crops in the park.

Mormon crickets provide an important source of food for many birds, small mammals and fishes. Tyus (1988) documented significant utilization by endangered fishes within the monument.

Mormon cricket populations have reached gregarious/migratory levels within the monument only twice during the past 30+ years. During the mid-1970s, high populations were observed on Douglas Mountain. High populations occurred on Blue and Wild Mountains during the early 1980s.

Treatment programs were conducted outside the monument in both the 1970s and 1980s using carbaryl (bran bait and aerial spray formulations) and malathion (aerial spray). Although the reduction in populations were assumed to be considerable in treated areas, monitoring for efficacy was limited at best.

Many concerns have been raised about the impact of these chemical agents on non-target organisms. Of particular concern are endangered peregrine falcons and endangered fish and their respective prey bases. Biological Opinions issued by the U.S. Fish and Wildlife Service pursuant to Section 7 consultations have constrained the amounts and formulations of chemicals which may be used in treatment programs as well as the locations which may be treated.

Treatment within the monument occurred only in 1976. A natural pathogen, Nosema locustae, was utilized in an experimental program. Despite many influences which reduced the viability of the spores, that particular test program was quite effective in reducing Mormon cricket population levels.

In 1985 another endemic pathogen was discovered in Mormon cricket populations in the monument. Varimorpha spp. has not yet been fully described. However, through both field observations and laboratory experiments, it has proved to be an extremely virulent pathogen in Mormon crickets. Population reductions subsequent to

exposure to this pathogen have rivaled those observed with chemical agents. The major reduction in regional populations has been attributed the to effect of Vairimorpha.

Monitoring efforts indicate that populations of Mormon crickets have remained very low in the monument since the mid-1980s. Decreasing populations, Section 7 constraints, questions about efficacy of chemicals, concerns about impacts to non-target organisms, high costs of treatment, and recognition of natural food habits of Mormon crickets have combined to virtually eliminate major treatment programs on public lands outside the monument. Some relatively minor baiting of Mormon cricket egg beds does occur on federal and private lands outside the monument in most years.

Incidental monitoring of crickets will continue within the monument. If populations show a significant increase, monitoring within and near the monument will be intensified. In 1991, for example, indications of increased cricket numbers triggered an intensified monitoring effort within the park. That effort was reduced by mid-summer when it was evident that populations within the monument were small and scattered.

6. VEGETATION

a. GENERAL FLORA

About 650 species of vascular plants have been collected and identified in Dinosaur National Monument. Botanists expect that another 200-250 species might be located through more intensive surveys.

A vegetation type map (resolution of 2.5 acres) was prepared from color aerial photos (1:12,000) taken in 1985. This map is available for digitizing and GIS use.

The distribution and abundance of many plant species and communities has been significantly altered by human activity since European occupation. Those activities which have most contributed to change are grazing by domestic livestock, suppression of wildland fires, and water impoundments or diversions. Large areas which are now dominated by sagebrush were probably grasslands prior to settlement. Pinyon-juniper woodlands are encroaching into other communities. Certain upland communities and associations are significantly reduced (e.g. giant mountain mahogany communities; grassland associations). Riparian communities have been drastically altered by invasion of tamarisk and loss of regular over bank flooding by the Green River (loss of condition conducive to reproduction of cottonwood, willow and boxelder).

Management will seek to restore natural, presettlement vegetation complexes over time through the use of prescribed fire, through termination of grazing in accordance with P.L. 86-729, and where necessary through more intrusive means such as reseeding and planting. More intensive management may be required to control non-indigenous plants.

b. RARE PLANTS

An inventory conducted by the Colorado Natural Areas Inventory in 1987-1989 located populations of nearly 40 rare plant species in the monument. Results included several new records for the park, new records for the County and State, several species listed as candidate or "threatened" on the Endangered Species List, and at least 2 species new to science. Naumann (1990) provides information on collections made during the survey and a listing of all plant species observed during the survey. The final report also provides detailed information about the rare species including location, elevation, geological substrate, non-park locations, biology and phenology, vulnerability and special management problems.

A rare plant monitoring plan for the monument was developed by the Colorado Natural Areas Inventory and Dinosaur National Monument. Implementation of that monitoring program began in 1992 but has been suspended due to lack of funds. About one-half of the initial baseline monitoring effort was completed. We expect that this program will serve as a prototype for Colorado Plateau parks.

c. NON-NATIVE PLANTS

Approximately 50 species of non-native plants are known from the monument. Of these, only a few are of ecological or economic significance. These include cheatgrass (Bromus tectorum), Russian knapweed (Centaurea repens), tamarisk or salt cedar (Tamarix pentandra), Russian olive (Elaeagnus angustifolia), giant whitetop (Cardaria draba or Lepidium latifolium) and some thistles. Leafy spurge (Euphorbia esula) is suspected to occur in the monument but its extent is still unknown.

Monitoring, mitigation and/or research activities will be proposed for many of the non-native species.

d. NON-VASCULAR PLANTS

Non-vascular plants include lichens, mosses, algae and microbiotic soil crusts. Some aquatics have been collected during studies on the Green and Yampa Rivers in the 1960s and 1970s. Inventories should be completed for aquatic non-vascular plants.

Research on lichens (inventory and baseline air pollution) began in 1991. Several reference sites were established to provide for baseline and future monitoring of air pollution loading; a lack of funding has precluded chemical/pollutant analysis from the reference sites. The baseline inventory of lichens has not been completed due to lack of funding. Initial collections found known lichens on substrates and at elevations not previously reported. Several species apparently new to science were also collected. Researchers suspect that over 200 species may eventually be found in the monument. This inventory and elemental analysis of collections from reference sites should be completed as soon as possible.

Management interest is related primarily to potential use of lichens as bioindicators of air pollution.

e. RIPARIAN COMMUNITIES/WETLANDS

Various types of wetlands and riparian communities exist throughout Dinosaur. Riparian communities are fairly distinct along the Green and Yampa Rivers, with expanded communities in areas such as Deerlodge, Harding Hole, Echo Park and Island Park. Riparian communities are also found along perennial and intermittent streams such as Jones Hole Creek, Alcove Brook, Rippling Brook, Cub Creek, and Pool Creek. Similar communities are located in areas with unnamed streams such as Hog Canyon, Blind Canyon and various side canyons to the main river system. Some of these communities are dominated by cottonwood or boxelder. Others have a wide range of woody species including river birch, various willows, hackberry and the like. Phragmites, sedges and rushes are common in many riparian zones.

In several places there are bog communities associated with springs and seeps. These are most common at higher elevations on Wild Mountain, Douglas Mountain and the north slope of Blue Mountain. Some are heavily used by elk and other ungulates.

Hog Canyon is the site of a proposed riparian restoration demonstration project. Monitoring was conducted in 1991 to characterize the hydrologic systems and vegetation communities associated with Hog Canyon. As noted earlier, that area is the site of intensive monitoring of *Spiranthes diluvalis*, an orchid listed as "threatened." Monitoring, interagency coordination and environmental compliance efforts have continued through 1993. During the fall of 1993, the stream in Hog Canyon was experimentally "relocated" into a native channel. If monitoring indicates that the experimental relocation does not diminish water yield to Cub Creek, the stream relocation may become permanent.

Dinosaur also contains many unique and significant hanging gardens. A sample of these were examined as part of a Colorado Plateau, multi-park research effort in the early 1990s.

Most of the riparian communities and wetlands in the monument are poorly known. Management interest lies in (1) an inventory and characterization of wetlands and riparian zones and (2) the riparian rehabilitation project in Hog Canyon.

f. FIRE MANAGEMENT

Dinosaur National Monument is currently conducting a complex fire management program pursuant to an approved (1908, 1991) Fire Management Plan. The plan provides for management of wildfires, prescribed natural fires and prescribed fires. The plan identifies fire management objectives, policies and zones; establishes guidelines for evaluation and classification of fires; directs the monitoring and/or management of fires; and encourages coordination and cooperation with adjacent agencies. Fire management activities include fire prevention, presuppression, hazard fuels management, detection, suppression, management-ignited prescribed fires, prescribed natural fire management, fire effects monitoring and other monitoring and research efforts.

Nearly all fire management activities are currently funded by the Normal Fire Year Programming process, better known as FIREPRO.

Readers are directed to the Fire Management Plan for greater detail on all aspects of the fire management program.

D. PALEONTOLOGICAL RESOURCES

With the exception of the Dinosaur Quarry and the Morrison Formation, relatively little is known about the paleontological resources in Dinosaur. Many of the rock formations within Dinosaur occur widely in the western U.S. and a review of the scientific literature on those formations makes it likely that hundreds, if not thousands, of species of fossils remain to be documented within the monument.

For ease of discussion, paleontological resources are herein treated by era of occurrence. In the following discussions the term "paleontological resources" includes vertebrate, invertebrate, paleobotanical, and trace fossils.

No Dinosaur paleontological data is in a GIS-ready format.

Stereo air photos (both black and white and color) have been taken of the park. However, the scale of these photos (1:12000) is too coarse for some detailed plotting of localities. Finer scales (as fine as 1:3000) will be needed.

1. PRE-CAMBRIAN

Nothing is known about fossils in the Pre-Cambrian rocks within the monument. Pre-Cambrian fossils are extremely rare world-wide and may well not be present within the monument. Only one Pre-Cambrian rock unit is known within the park (see Fig. 1).

2. PALEOZOIC

Eight Paleozoic formations occur within Dinosaur (see Fig. 1). No systematic inventory work has been done for Paleozoic paleontological resources. A few geological studies have described paleontological materials in passing (Driese 1982, Maione 1971, Untermann and Untermann 1954) but such information is scarce and scattered, and the data in these works is not sufficient to serve as baseline data. Paleozoic paleontological resources are mentioned in the series of USGS quadrangle maps which cover the monument (Hansen 1977a, 1977b, 1978; Hansen & Carrara 1980; Hansen, Carrara, & Rowley 1980; Hansen & Rowley 1980; Hansen, Rowley, & Carrara 1983; Rowley, Dyni, Hansen, & Pipiringos 1979; Rowley & Hansen 1979a, 1979b; Rowley, Hansen, & Carrara 1981; Rowley, Kinney, & Hansen 1979). However, once again this is done only in a very general way and does not constitute baseline data. Parrish (pers. comm. 1983) reported that personnel from the University of Chicago had collected trilobites from the Lodore Formation (Cambrian) in the Jones Hole area in the early 1980's, but no additional information is available concerning the specimens. Park staff collected trilobite trace fossils (Cruziana) from the Lodore Formation of the Jones Hole area. In 1953 Barnum Brown and Gil Stucker (American Museum of Natural History, N.Y.) collected a series of invertebrates from the Morgan Formation within Split Mountain. These specimens have been identified by US Geological Survey specialists and the park has a representative sample of these identified fossils in its collections. However, the park's locality data for these specimens is poor although better information may be available from the USGS. As poor as the Morgan collection is in terms of systematic coverage, it represents the best collection of Paleozoic invertebrates within the monument.

3. MESOZOIC FOSSILS

Twelve Mesozoic formations occur in the monument (see Fig. 1). Many of the Mesozoic formations within DINO have extensive exposures throughout the southwestern and western U.S. A review of

the scientific literature shows that abundant, diverse and significant fossil floras and faunas have been found within all of those formations. In some cases, these faunas are known from exposures immediately adjacent to monument boundaries in horizons which continue into the monument. Therefore, it is likely that similar types of resources occur within the Mesozoic formations of Dinosaur.

With the exception of the Dinosaur Quarry only limited data exists for Mesozoic plant and animal communities. In some rocks, such as marine formations, this lack of information simply reflects a lack of collecting and scientific study. In other cases, the lack of information may reflect the actually rarity of organisms at that time. Such differences will only be identified through continued studies. The park does not have a representative collection of common marine invertebrate fossils, a surprising fact considering the abundance and diversity of this resource in Paleozoic and some Mesozoic formations.

No systematic baseline inventory has been completed for any Mesozoic formation within the monument. Much of what is known in formations other than the Morrison Formation is the result of incidental, non-systematic field work. Bakker (pers. comm. 1984) showed park staff where he had collected Deinonychus and ankylosaur material from the Cedar Mountain Formation. Subsequently, park staff collected part of a sauropod dinosaur from the same site. Engelmann collected a small reptile femur from another locality in the Cedar Mountain in 1984. Park staff have collected fish jaws, a partial fish skull, and leaves from the Mowry Shale, a formation which does not generally yield other than isolated fish scales. An angiosperm leaf and shark teeth have been collected from the Frontier Formation by park staff.

In 1990 several 3-year contract studies began which focus on systematically inventorying paleontological resources in the Upper Jurassic Morrison Formation and inventorying vertebrate fossil trackway resources in the Moenkopi, Chinle, Navajo, Carmel, Entrada, Morrison, Cedar Mountain, and Dakota/Frontier formations. Only preliminary reports are available (Engelmann 1990; Turner & Peterson 1991; Lockley, Flemming, Conrad, & Farlow 1990.) but these show that abundant and significant resources do occur. Engelmann (1990) in the first two years of his survey identified 300+ paleo localities, some of which are so significant and threatened that immediate excavation was undertaken. Even so, these 3-year surveys will provide adequate baseline data for only a limited number of Mesozoic formations. Other formations will need similar detailed treatment.

Fieldwork conducted by outside researchers and park paleontological staff has shown that the Morrison Formation within the monument was deposited in a mosaic of environments. Some of these depositional environments, such as ponds and small lakes, are unusual in the Morrison and will require more detailed paleoecological study than that afforded by the broader scope of the three-year baseline projects. Such work is needed in order to understand the diversity and complexity of plant and animal communities within the Morrison.

Yen and Reeside (1950) describe and figure a few mollusks from the Morrison Formation within the monument. These specimens were collected by Earl Douglass in 1913, from a conglomeratic sandstone "near the Dinosaur Quarry". In spite of their abundance within certain horizons in the formation, this is the only publication describing Morrison mollusks from within the monument.

Two localities in the Morrison formation within DINO have produced hundreds of significant remains of the small vertebrates which were contemporaries of the animals preserved in the Dinosaur Quarry (Chure & Engelmann 1989; Chure, Engelmann, & Madsen 1989; Engelmann, Chure, & Madsen 1989; Engelmann, Greenwald, Callison, & Chure 1990). Many new species and several new genera are present at these sites and are currently (1991) under study by various researchers. Excavation and analysis of these and other important sites is a continuing long term project for park paleontological staff. Several other localities, primarily occurrences of single dinosaurs, have also been excavated by park staff.

Because of its location within the Visitor Center and the policy of leaving the fossils in-situ, the Dinosaur Quarry constitutes a special kind of Mesozoic paleontological resource which is managed in a manner quite different from other localities. Discovered by field crews of the Carnegie Museum in 1909, some 700,000 pounds of fossil vertebrates belonging to some 14 species were collected by that institution before they ceased operations in 1922. Both the Smithsonian and the University of Utah collected in the quarry during 1923. Between 1924 and 1953 no work was done in the quarry. The present Visitor Center was built over the Quarry and opened in 1958. The existing quarry is now 80% excavated and continued reliefing is a long term project for park paleontological staff. Most material within it has been catalogued and mapped.

The literature on the Dinosaur Quarry is substantial although many of the treatments are brief and much remains to be learned. The following is a summary of existing baseline data and needs for the Dinosaur Quarry:

4. HISTORICAL RECORDS

Although adequate materials exist, no comprehensive history of the Dinosaur Quarry has been written. Quarry history is summarized by Chure & McIntosh 1990; McIntosh 1977; and West & Chure 1984. However, these are brief, popular treatments and do not cover such history in detail. Harvey (1991) provides an interesting perspective on the Quarry history and the relationship between the NPS and the surrounding community, a viewpoint which has not been much explored. Other, shorter reports provide historical information on specific specimens which is not available elsewhere (Avinoff 1933, 1934, 1935, 1936, 1937, 1938, 1939, 1940, 1941, 1942, 1943, 1945; Holland 1910. 1911, 1912b, 1913, 1914, 1915a, 1916b, 1917, 1918, 1919, 1920, 1921, 1922, 1923, 1926, 1927, 1928, 1929, 1930, 1931, 1932; Kay 1951, Stewart 1924, 1925). Gilmore (1924a, 1924b) describes the Smithsonian work at the Quarry. Gilmore 1932 contains a quarry map of the USNM Diplodocus collected from Dinosaur and Gilmore 1936a contains a large, but incomplete, map of the Carnegie and Smithsonian excavations. Colbert (1968) discusses the place of the Quarry in the broad framework of the history of dinosaur study. McIntosh (1981) provides a comprehensive review of the Quarry specimens currently housed in the Carnegie Museum, but does not provide data on the large numbers of specimens in other repositories. McIntosh (pers. comm 1991) has compiled unpublished data on these additional specimens and has offered to make it available to Dinosaur. The park has an acetate negative of the map from the Carnegie Museum activities and the original field notebooks, paper and linen maps of the excavations, and lab preparation notes from the work conducted by the University of Utah.

"Monsters of the Past" is an 18-minute semi-commercial black and white movie shot by the Carnegie Museum in 1922 as a quasidocumentary of their collecting operations. This movie has a significance beyond Dinosaur as it is some of the earliest footage ever taken of the collection of fossil vertebrates. The original negative has apparently been lost or destroyed (Coggeshall 1983 pers. comm.). The monument made a copy negative in 1957 which is now the best negative in existence. Prints were made from the negative and a print was transferred to 3/4" videotape. The copy negative, one print, and the videotape are all accessioned and catalogued into the park's museum collection.

The University of Utah Libraries Special Collections Section is the repository for a large amount of holographic and photographic material of Earl Douglass which is related to his work at the monument. Cooley, Dye, & Ward (1982) provide a register of the materials in their holdings and excerpted select sections from some of them. The Monument's archives contain photocopies of selected portions of Douglass's diaries. Earl Douglass' son, Gawin

Douglass, has written a biography of his father which has not been published. A copy of this manuscript is also in the park archives.

During the 1930's Barnum Brown, a leading dinosaur paleontologist at the American Museum of Natural History, was involved in development planning for the Quarry Visitor Center. At present there is no information available on what documents are available at the American Museum relative to that period of monument history, but material almost certainly exists. Brown (1937) gives a popular account of a trip to Dinosaur and plans for its development, including a design for a Quarry Visitor Center.

Nevertheless, the baseline data within the monument concerning the quarrying between 1909 and 1924 and the caretaker period from 1924 up to the building of the modern Visitor Center in 1958 must still be considered inadequate. Large lacunae exist concerning specimens collected, their current location and identification, correspondence, historical photographs, development plans, etc. Such data is available but is scattered among some thirty institutions. There is no single map which contains all specimens collected from the Dinosaur Quarry. Although the several maps that do exist collectively contain nearly all specimens collected from the quarry, they are at different scales and some have serious problems with foreshortening and other inaccuracies. In addition, many specimens excavated between 1953 and 1958 did not have their locations plotted before removal. McIntosh (pers. comm. 1988) has photographs of an unknown percentage of these specimens before their removal and has offered to make these available to the park in order to make a map as complete as possible. All the maps need to be redrafted to a common scale, related to specimen data records, and prepared for GIS entry. Databases on collected specimens need to be compiled.

5. SCIENTIFIC STUDIES

Paleontological studies have been primarily morphological and descriptive in nature (Berman & McIntosh 1978; Britt 1987, 1991; Chure 1980, 1981: Chure & Engelmann 1989; Ellinger 1950; Fiorillo 1991a, 1991b; Galton 1977a, 1977b, 1980, 1981a, 1981b, 1982a, 1982b, 1982c, 1983; Galton & Jensen 1973a, 1973b; Galton and Powell 1980; Gilmore 1925a, 1925b, 1932, 1936a; Holland 1915b, 1915c, 1916a, 1924b; McIntosh 1981; McIntosh & Berman 1975; Madsen 1976; Rothschild, 1990; White 1958). Although these studies have focused on dinosaurs, some have examined turtles (Gaffney 1979; Gilmore 1916) and crocodilians (Gilmore 1926, Kay 1951). No scientific studies have been done on the non-vertebrates found in the quarry (such as the abundant unionid bivalves) although Bilbey (pers. comm. 1988) has collected ostracods and charophytes from clay lenses in the west end of the present Quarry.

A number of publications have looked (at least in part) at the Quarry in a larger context, such as paleobiogeography (Galton 1977a, 1977b, 1980, 1981a, 1982a, 1983), taphonomy (Dodson, Bakker & Behrensmeyer 1983; Dodson, Behrensmeyer, & Bakker 1980; Dodson, Behrensmeyer, Bakker & McIntosh 1980; Lawton 1976, 1977 -- although only the last author looks at the Quarry in detail), and Morrison paleoenvironments (Dodson, Bakker, & Behrensmeyer 1983; Dodson, Behrensmeyer, & Bakker 1980; Dodson, Behrensmeyer, Bakker & McIntosh 1980).

6. INTERPRETIVE PUBLICATIONS

McIntosh (1977) and West & Chure (1984) are the best general interpretive publications covering the Quarry. Other popular articles (including those not written by park staff) are Anonymous 1982; Chure 1987a, 1987b, 1990, 1991; Chure and McIntosh 1990; Gebhart 1991; Gilmore 1924a, 1924b, 1936b; Good 1957; Good, White and Stucker 1958; Gordon 1991; Hamilton 1961; Hyde 1956; Keller 1973a, 1973b; Kerourio 1980; McGinnis 1982; Mehls 1990; Pearl 1975; Schaffer 1987; Voynick, 1988; White 1964, 1967). The quality of these publications varies considerably, from accurate summaries (Chure and McIntosh 1990) to works so riddled with errors as to be completely useless (Gordon 1991). Colbert (1977), in a popular work on the life of Morrison sauropods, refers to the evidence from Dinosaur which he used in his paleobiological speculations. Anonymous (1980) is concerned with the discovery of a juvenile Stegosaurus in the Quarry, while E.P.W. (1987) describes the process of molding the juvenile Camarasaurus lentus for the Quarry Visitor exhibits.

The concept of a building over a quarry and a laboratory where the public can view preparation are concepts that have been adopted at a number of other fossil localities managed by local, state, and federal agencies. Jain (1969) describes an attempt (which was ultimately unsuccessful) to develop a site in India in the manner done at Dinosaur.

7. CENOZOIC FOSSILS (INCLUDING QUATERNARY)

Two Cenozoic formations and several types of unconsolidated Quaternary surface materials occur within the monument (see Fig. 1). Very little is known about Cenozoic paleontological resources within the monument. Only two non-Quaternary Cenozoic formations within the monument (Bishop Conglomerate, Browns Park). Although no fossils are known from these formations within the monument, they have produced fossil material (both skeletal and footprints) in exposures near the park. In 1989 a limited preliminary study on Quaternary resources (pack rat middens) was conducted by a graduate student from Northern Arizona University (Sharpe 1991). However,

considering the abundance of Quaternary fossils elsewhere on the Colorado Plateau the chances are high that significant undocumented resources are present within Dinosaur.

In 1983 several caves were discovered and mapped in the Jones Hole Creek valley by spelunkers from Colorado (Davis 1983, Scoville 1983, Rhinehart 1983). Although no fossil bone was reported to the park by the mappers, caves can serve as traps for Pleistocene fossils and these caves need to be examined for fossils. The extensive limestone within the monument is likely to contain similar caves. A systemtic survey of the park for caves needs to be conducted and all caves need to be paleontoloigcally inventoried. This survey would include caves high on canyon walls, as such features have yielded significant fossils in other NPS areas (Emslie 1986).

8. PALEONTOLOGY/GEOLOGY RESEARCH LIBRARY

The Research Library housed within the Quarry Visitor Center contains some 10,000 books, journal volumes, and scientific papers. It is particularly strong in the area of dinosaur literature. Lesser holdings include publications on Mesozoic fossil vertebrates, fossil fish, fossil amphibians, and fossil birds. Meager holdings in geology concentrate on formations which occur within the monument. A card catalog, consisting of hand typed 3x5 index cards, covers much of the library. The holdings are not computerized.

The library is an essential tool for the paleontological program at Dinosaur. It provides primary scientific data for research, resource management, and interpretation of fossil resources. The library is used heavily by existing staff and by visiting researchers. It is also used by regional and local paleontologists and geologists.

Attempts to keep the library current focus on an xeroxing and reprint request program. However, due to other demands, this program is not as thorough as is needed. Journal subscriptions include one major paleontology journal, but others which are needed and/or were formerly subscribed to are not currently subscribed to. No geology journals are subscribed to, although some had been in the past.

9. PALEONTOLOGY LABORATORY

The paleontology laboratory is where collected fossils are removed from the rock and receive stabilization and conservation treatment. Preparation is accomplished using a variety of mechanical (both manual and powered) and chemical agents. At present, one half the

laboratory is utilized as a storage area for paleontological museum specimens. This results in a cramped work are for preparation staff, with concomitant threats to the specimens. An inspection by Regional Industrial Hygienist in 1991 documented that serious employee health and safety issues exist in the laboratory . The fume hood does not have gas lines to allow for the use of bunsen burners in heavy liquid separation of microfossils. Particulate matter and fumes generated by preparation and conservation activities is poorly and inadequately controlled. Air turnover in the lab is poor. Radon is emitted by some fossil specimens and can build to dangerous levels within cabinets. Additional equipment is needed to improve the efficiency of conservation and preparation activities.

10. LANDS

Significant fossil resources occur on non-NPS lands within and adjacent to the monument. There are no cooperative agreements with the land management agencies responsible for those lands. Fossils on those lands are important for understanding and evaluating the fossils on NPS lands and co-operative management agreements would improve the protection of those resources.

The Utah State Land Board has proposed new management policies that would result in the sale of fossil resources from state school sections. Such sections occur within the monument or are adjacent to monument boundaries. No inventories have been done of these inholdings and thus the monument does not have a sufficient base for evaluating the suitability for purchase for all sections subject to fossil resource sale.

E. GEOLOGICAL RESOURCES

There are twenty-three formations exposed within Dinosaur, not including unconsolidated Quaternary surface materials (see Fig. 1). These rocks date back to over one billion years in age and make for the most complete rock record within any NPS Unit. This, coupled with the spectacular nature of the exposures and the complex geological structural history of the monument, makes Dinosaur an excellent area for geological research. See Figure 2 for a Geological Time Scale.

Although the geological history of the monument is fairly well understood in broad terms, it is not clear what geological questions remain that can be addressed within Dinosaur. Nor is it clear what constitutes significant geological resources within the monument. Answering these questions is necessary in order to identify issues and develop management actions to protect these

resources. Until such information is available, geological resources will not be adequately addressed in Dinosaur's RMP.

In 1983, several caves were discovered and mapped in the Jones Hole Creek Canyon (Davis 1983, Scoville 1983, Rhinehart 1983). These are the only caves (in a speleological sense) that are known in the park. However, considering the extensive limestone within the park and the almost total lack of speleological activities it is likely that other cave systems exist within Dinosaur's boundaries.

Very little radiometric dating has been done within the monument. Only the Morrison has had several dates run on it within the monument. Thus, no framework of absolute dates exist for the monument's geologic record, although ages have been inferred from other radiometrically dated areas and contained fossils.

The monument has nearly complete coverage through a series of twelve USGS Geological Quadrangle Maps (Hansen 1977a, 1977b, 1978; Hansen & Carrara 1980; Hansen, Carrara, & Rowley 1980; Hansen & Rowley 1980; Hansen, Rowley, & Carrara 1983; Rowley, Dyni, Hansen, & Pipiringos 1979; Rowley & Hansen 1979a, 1979b; Rowley, Hansen, & Carrara 1981; Rowley, Kinney, & Hansen 1979). Only the Canyon of Lodore North remains to be completed. These maps summarize the historical and structural geology for each quadrangle. The scale of these maps is 1:24,000, with the exception of the map by Hansen, Rowley, and Carrara (1983) which is 1:50,000. Unfortunately, none of these geological maps differentiate between the Morrison formation and the Cedar Mountain Formation which immediately overlies it. Work currently underway on Morrison sedimentology and stratigraphy within the monument have identified a previously unrecognized member of the Morrison (Tidwell Member) within the monument and have clarified boundaries with the Cedar Mountain (Turner & Peterson 1991). Remapping of the Morrison is sorely needed and should be done as a strip map at a smaller scale than that on the existing USGS maps so that members can be identified. Mapping of other formations may also need redoing at a smaller scale.

Stereo air photos (both black and white and color) have been taken of the park. However, the scale of these photos (1:12000) is too coarse for some detailed geological mapping. Finer scales (as fine as 1:3000) will be needed, especially in sedimentologically and stratigraphically complex terrestrial formations.

Many geologists have made studies within Dinosaur or have studied Dinosaur as part of a larger geological research project. However, the monument does not have copies of most publications from such work nor does the monument have a complete list of citations for such studies. This is a major and serious gap in the geological

baseline data of the monument. Although the USGS Geological Quadrangle Maps do include references to significant publications on the area, this may not be a complete list. Such information is important not only because of what it tells us about the geology of Dinosaur but also may identify sites or areas which are of such geological significance that special management actions may be needed.

The following is a partial listing of geological studies conducted totally or in part within the monument:

General geological reviews: Evanoff & Gillam 1987; Hansen 1969a; Powell 1876; Untermann & Untermann 1949a, 1954, 1964, 1969, and the USGS Geological Quadrangle Maps (Hansen 1977a, 1977b, 1978; Hansen & Carrara 1980; Hansen, Carrara, & Rowley 1980; Hansen & Rowley 1980; Hansen, Rowley, & Carrara 1983; Rowley, Dyni, Hansen, & Pipiringos 1979; Rowley & Hansen 1979a, 1979b; Rowley, Hansen, & Carrara 1981; Rowley, Kinney, & Hansen 1979)

Development of the Green River drainage system: Hansen 1969b, 1986

Development of Yampa River canyon: Sears 1962

Radiometric dates: Bowman, Bowman, & Drake 1986; Kowallis, Christiansen, & Deino (in press)

Speleology: (*****add citation****)

Geochemistry: Bilbey 1973

Specific studies (stratigraphic, structural, etc. including larger studies when part of the work was conducted within Dinosaur or refers to such work in a meaningful manner): Baker, Dane, & Reeside 1936; Bilbey 1973; Bilbey, Kerns, & Bowman 1974; Bissell 1964; Bradley 1952; Craig et al. 1955; Driese 1982, 1983, 1984, 1985; Fritz 1977; Hintze 1973, Kayser 1964; Kinney 1955; Lawton 1976, 1977; McCann, Raman, & Henbest 1946; McCormick & Picard 1969; MacLachlan 1957; Maione 1971; Poole & Stewart 1964; Preston 1957; Robison 1964; Sadlick 1957; Smith & Cook 1985; Stokes 1957, 1986; Turner & Peterson 1991; Untermann & Untermann 1949b, 1950; Uygur & Picard 1985; Williams, J.S. 1969; Williams, N.C. 1957; Young 1987

F. AIR, WATER AND LAND USE

1. WATER RESOURCES AND RELATED ISSUES

a. YAMPA RIVER ECOSYSTEM

The Yampa River is the only remaining large tributary to the entire Colorado River System which is free of major instream impoundments. Its natural, aesthetic, recreational and scientific values are therefore unique and of ever-increasing importance.

In 1938, Dinosaur National Monument was expanded to include portions of the Yampa and Green Rivers and their spectacular canyons. Among the most critical resource problems confronting Dinosaur today are threats to the integrity of the Yampa River and the Green River below its confluence with the Yampa. Construction and operation of any of several proposed water developments would severely diminish the natural, ecological, scientific, recreational, aesthetic and scenic values for which the monument was expanded. The values at risk and the potential impacts on those values need to be described qualitatively and quantitatively. Unregulated flows at present maintain the natural character of the Yampa River and its canyons. Natural Yampa River flows also ameliorate the effect of regulated Green River flows below their confluence. Thus the natural Yampa River flows are the primary factors sustaining near-natural river and river corridor systems throughout much of the Upper Colorado River Basin.

The impacts of less than natural flows can be grouped according to their effects on (1) the physical/chemical environment, (2) ecosystem (biotic) maintenance, (3) aesthetics, (4) recreation and (5) scientific values. Projected changes in the physical/chemical environment are inextricably tied to changes in other categories.

Potential impacts of less than natural flows on the physical/chemical environment include:

- a change in flow levels, especially the reduction of high flows and the increase of low flows.
- a concurrent change in sediment transport. These two changes would be critical to the Yampa River and its appurtenant values. Loss of these high flows and the bed load movement would irrevocably alter the Yampa and its natural character.
- a change in seasonal flow patterns.
- probable creation of diurnal flow fluctuations.
- a change in the temperature regime (colder or warmer).
- a change in turbidity.
- a change in amount and nature of dissolved solids.

- a change in dissolved oxygen and other dissolved gas levels.
- a change in salinity.
- a change in ion balance.
- changes in other water quality parameters.
- changes in patterns of erosion and deposition.
- probable losses of beaches and sandbars.
- a change in the level and pattern of undercutting of cliffs/rocks.
- river bed armoring.
- possible channelization - a fixing and deepening of the channel.
- possible loss of driftwood renewal.
- a possible change in "rapids" morphology with loss of high natural flows (side stream flash floods could create new, possible unrunnable rapids that the mainstream could not modify).
- possible loss of or reduction in seepage/recharge rates along the Yampa.
- possible change in groundwater recharge.

Potential impacts of less than natural flows on ecosystem maintenance include:

- changes in the types, distribution (temporal and spatial), quantity, and quality of habitats for fish and other aquatic organism with resultant changes in species diversity and abundance of those fish and other organisms.
- probable extirpation of four endangered fish species throughout most of the Upper Colorado River Basin. Most of the remaining ranges of the Colorado squawfish, humpback chub and bonytail chub lie in the Upper Colorado River Basin. Specifically, the potential and probable impacts include the loss or reduction of spawning habitats in the Yampa; loss or reduction of fish rearing habitats (shallow backwaters or shorelines with emergent vegetation); loss of other requisites for survival or reproduction due to alterations in flow regimes, flow levels, temperatures, "naturalness", etc.; possible increased competition with exotic species if modified habitats and more amenable to those exotics; possible increased hybridization with closely-related non-endemic species if modified habitats are more amenable to those non-endemic species.
- changes in species diversity and abundance of benthic organisms.
- changes in species diversity and abundance of aquatic (submergent and emergent) vegetation.
- changes in species diversity and abundance in riparian communities with loss of high flows and possible establishment of diurnal fluctuations. Included are: reduction in diversi-

ty and abundance of animal (particularly avian) species using these habitats; reduction or loss of box elder and cottonwood regeneration (due to loss of flooding) resulting in eventual deterioration of the stands and reduced diversity and abundance of animal (particularly avian) species using these habitats; invasion of phreatophytes (especially

- tamarisk because tamarisk grow in closed monotypic stands, the diversity of animals using these sites would probably decline significantly); loss of nutrient replenishment associated with flooding; and changes in moss communities which occur at high water levels.
- depletion of plant and animal communities associated with driftwood piles.
- reductions in those specialized communities that currently exist between high water and low water lines with the progressive and relatively predictable recession of water in summer.
- a change in species composition and abundance of vegetation near (and below) water line with a change pattern (and number of days) of submergence due to diurnal fluctuations.
- a change in successional patterns, particularly in riparian zones.
- the loss or reduction of temporal communities in temporal backwaters.

Potential impacts of less than natural flows on esthetics include:

- a diminished scenic mosaic, particularly with changes in riparian vegetation, loss of regeneration of cottonwood and box elder groves, invasion tamarisk, the loss of widely varying flow levels and water colors, and the alteration of river landforms;
- the creation of an artificial "bathtub ring" on shoreline rocks and cliffs;
- the intangible loss of free-flowing characteristics, particularly in the minds of visitors and potential visitors.
- the diminished integrity of values for which Dinosaur was expanded in 1938 (scenic, scientific, natural, recreational);
- the diminished integrity of proposed wilderness and its intrinsic values; and
- the diminished integrity of those values which warrant the Yampa's consideration for designation as a "wild" river within the National Wild and Scenic River System.

Potential impacts of less than natural flows on recreation include:

- the impacts on esthetics noted above.
- a reduced quality of whitewater experiences - long stretches of slow flat water; rapids which cease to exist with flows of less than about 5,000 cfs, increased possibilities of being

stranded on rocks or above rapids by low flows, etc. In a survey of non-commercial boaters, 93 percent of the respondents felt the loss of high spring flows on he yampa from a recreational viewpoint would be an"extremely high loss: or a "high loss". If "moderate loss" were included, the percentage of respondents noted would rise to 96. In the same survey, 88 percent of respondents felt that an "extended season with calm placid conditions on the river "with very little whitewater and some shallow rocky stretches" would be of "slight value" or "no value".

- decreased Yampa and Green River use because of declining quality of whitewater experiences. There are a total of 300 launches available, of which about 100 are available on he Yampa when flows usually equal or exceed 5,000 cfs. Of the 1,611 non-commercial applications received in 1981, 53% (852) were for 100 high water Yampa launches (33% of total launches). If all launches during high Yampa flows are included 85% (1,257) of all applications are for less than half of the total launches available. Only 254 applications (15% total) were received for those periods when Yampa flows usually fall below 5,000 cfs and 85% (216) of those were for the Green River.
- reduced opportunities for a wide range of experiences (both high and low flows may be moderated).
- significant adverse economic impacts on commercial outfitters and regional economies with different equipment requirements and less visitor demand (due to lower flows and the reduced quality of whitewater experiences). In a study of the 1981 river season, it was calculated that outfitter business has a direct regional effect of about $1,637,000 per year with indirect benefits of $4,272,000 per year.

Potential effects of less than natural flows on scientific values include:

- the irretrievable loss of opportunities to study and understand the physical and biotic components (and their interactions) of a unique, rare and naturally functioning river system.

Less than natural flows may also affect potential special Congressional designations of the Yampa River and its canyons. The Yampa River and canyon country are included in the proposed Dinosaur Wilderness. Less than natural flows and their unnatural ecological effects would diminish the values which warranted proposal of the area as a Congressionally - designated Wilderness. The Yampa River has been found to possess such outstandingly remarkable scenic, recreation, geologic, cultural and fish and wildlife values as to warrant its consideration for designation as a "wild" river within

the National Wild and Scenic River System. Less than natural flows could seriously diminish these values. The Yampa River is proposed critical habitat for all 4 endangered fish species. Less than natural flows would adversely modify critical habitat.

There are currently more than twenty proposals to impound the Yampa River and/or its tributaries. There are several other proposals for significant withdrawals from instream flows. The construction and operation of some of these projects could result in the potential impacts noted above. The net effect would be to severely diminish the values which warranted the inclusion of this area in the National Park System.

During the early 1980s, several research projects were conducted to provide data for Dinosaur's instream flow water right adjudication. Included were studies of sediment transport (O'Brien 1984, Elliiot et al 1984), riparian vegetation (Fischer et al. 1980), endangered fish (Tyus et al. 1987), primary production (Annear 1980), etc. Various studies funded or conducted by the Fish and Wildlife Service, Bureau of Reclamation, Colorado Division of Wildlife and Utah Division of Wildlife Resources related to the endangered fish have continued to the present.

Current actions by monument staff are limited to (1) reviewing and commenting on environmental documents prepared by other agencies and/or proponents of water developments and various energy related projects; (2) providing logistical support for other agency and university sponsored research; and (3) keeping photo records of selected river reaches at various flow levels (this last action has been suspended due to a lack of funds).

These photos may provide a partial basis for assessing the relationships between flow characteristics and various values (e.g. recreation, esthetics, etc) and resources by natural flows. The present level of staffing, however, precludes opportunities for careful analysis of these photos.

At least four avenues of research should be continued:

1. A study of the relation of natural Yampa flows (and their times of occurrence) to the scenic resources and aesthetic values of the river canyon.
2. A continuation of the sediment transport research begun in 1982. The data collected in 1982 may be somewhat biased by the anomalous, even unprecedented, flow pattern of the 1982 season. Collection of data for even a single additional field season will produce significant increases in the sufficiency of the data and the ability to quantify volumes and times of flow necessary to maintain

the natural resources, values and ecosystem processes of the Yampa River ecosystem. In particular, the sediment transport research should: (a) examine the stages and durations of flow necessary to maintain the variety of channel patterns in the monument's canyons; predict changes which may result from altered flow regimes, (b) determine the origins of sediment transported through the monument as a function of drainage basin (as this may have an influence on native endangered fish migrations), (c) examine the sediment regimes of the Little Snake and upper Yampa and compare times at which they characteristically function, (d) determine the flow and sediment transport characteristics necessary to maintain the Colorado squawfish spawning site; predict changes in the spawning habitat which may result from any alterations in flow and sediment regimes.

3. An extension of the research initiated in 1982 on the relationship between levels/timing of flows and the maintenance of natural riparian vegetation. This study should examine particularly the relation between flows and (a) the regeneration of native riparian vegetation and (b) the removal/inhibition of exotic vegetation (tamarisk). Some of this is included in the riparian research initiated in 1993.
4. Continuation of the studies of the endangered fish, with particular focus on the relation between flows/times, habitat availability and various life stage requirements of the fish; genetic questions; olfactory clues for spawning areas; use of seasonally-flooded areas; etc.

The research should yield information to (1) document the levels, timing and other characteristics of flows necessary to sustain natural park resources and values and (2) accurately assess the individual and cumulative impacts of proposed water developments.

b. GREEN RIVER ECOSYSTEM

The Green River originates in the Wind River Mountains of Wyoming, flows south through Wyoming and Utah, east into Colorado, and enters Dinosaur National Monument at the east end of Browns Park. After it passes through Lodore Canyon (about 20 miles), it is joined by the Yampa River in Echo Park. The enlarged Green River then flows through Whirlpool Canyon, Island Park and Split Mountain Canyon, leaving the monument some 26 river miles below Echo Park.

The Green River was impounded in 1962 by Flaming Gorge Dam about 45 river miles above the monument. Significant changes occurred in that river system as a result of impoundment and regulated flows.

Regulated flows from Flaming Gorge have generally been low during the spring and summer months, increased through the fall and remained relatively high through the winter. From closure through 1978, water temperatures were quite cold, so much so that the trout fishery established below the dam shifted downstream into Lodore Canyon. In 1978, penstock modifications were made to increase the temperature of released water, resulting in the trout fishery being "drawn" back upstream. With the loss of suspended sediment in the reservoir, waters from the dam are also quite clear.

The effects of Flaming Gorge Dam are quite evident in Dinosaur National Monument. The sediment transport system is starved of input, except for episodic impulses from Red Creek and Vermillion Creek. Islands and sandbars have stabilized in some localities. In others the banks have eroded and the river bottom has become armored.

Riparian zones, with the loss of spring flows and over bank flooding, have narrowed. Tamarisk has established along much of the river. In Lodore Canyon the tamarisk were generally sparse and lacked vigor (except after high flows in 1983 and 1984; see below). Below the confluence with the Yampa River, tamarisk stands are dense and vigorous, often displacing native riparian communities. Cottonwood typically disperses seed during the period when peak flows begin to subside. Seeds then fall on a moist substrate and germinate without repeated inundation. Regeneration of cottonwood has been greatly reduced with the loss of high flows and over bank flooding. The flow regime, with diurnal fluctuations, favors establishment of tamarisk which disperses seed throughout the summer months.

In 1983 and 1984, unusually high flows (10,000 to 13,000 cfs) were released and spilled from Flaming Gorge. Two vegetation responses were striking. Cottonwood regeneration was evident along major reaches of the river, particularly in and below Echo Park in areas where the combined Green and Yampa River flows resulted in overbank flows. With the absence of high flows in succeeding years, however, much of that regeneration has been lost. Above Echo Park (Lodore Canyon), tamarisk regeneration greatly increased on newly wetted areas. Absence of scouring flows during succeeding years allowed those new stands to become established. Within Lodore Canyon, tamarisk stands today are much more extensive and vigorous than before 1983.

Effects of the modified flows are also evident in faunal communities, especially above Echo Park. After closure of the dam, some components of the macroinvertebrate fauna were lost. Other species, more common to cool water mountain streams, have appeared. Native fish populations have been significantly reduced. The

endangered species have been virtually extirpated (occasionally an individual Colorado squawfish will travel up Lodore Canyon). Trout, channel catfish and carp are common in Lodore Canyon. Below Echo Park, the ameliorating influence of the Yampa River has sustained most native components of faunal communities, although non-native fish species predominate.

In the early 1980s, the U.S. Bureau of Reclamation requested consultation with the U.S. Fish and Wildlife Service pursuant to Section 7 of the Endangered Species Act. Several research projects were conducted in the Green and Yampa Rivers to assess the effect of Flaming Gorge Dam on the endangered fish. In 1991, a "jeopardy" opinion issued by the Fish and Wildlife Service. Reasonable and prudent alternatives offered by FWS include reoperation of Flaming Gorge Dam to more closely simulate the natural hydrograph. Experimental releases will be used from 1992 through 1996 to examine the effect of various flow regimes on endangered fish and their habitats.

Sediment dynamics research has been initiated to document existing sediment patterns and their relationship to past flow regimes; document the relationships among flows and sediment dynamics and (1) establishment and maintenance of endangered fish habitats, (2) establishment and maintenance of riparian communities and (3) structures important to recreational use (e.g. sandbars, campgrounds). Riparian research focus on the relationship between flows and the establishment and maintenance of riparian communities, the effect of herbivory on riparian communities, the effect of bank storage on riparian communities, and the like. The results of these studies will be incorporated with endangered fish studies in 1997 to establish a long-term release regime for Flaming Gorge Dam.

Preliminary results indicate that flows of 10,000 cfs or greater would be necessary in Lodore Canyon to "recreate" bank and vegetation conditions similar to those which existed prior to closure of Flaming Gorge Dam. The danger exists, however, that with the relative lack of sediment input into Lodore, such flows may have an adverse effect on sediment balances.

c. WATER RIGHTS

As a part of the McCarren Amendment general stream adjudication in Colorado, the United States was joined as a party for the purpose of establishing the reserved water rights of Dinosaur National Monument.

Colorado has an appropriative system in which water rights are established under the principle of first in time is first in right.

Water rights existing before the monument was established, therefore, would not be affected. Rights established later might be affected because they would be junior to the NPS water rights for Dinosaur.

The reserved rights claimed by the NPS were basically the minimum amount of water necessary to sustain the primary (as distinguished from secondary) purposes for which the area was established. The priority date for these water rights would be the date the monument was enlarged to include the Yampa and Green River canyons, namely 1938.

The Colorado Supreme Court, in review of the lower court decision, sustained the Department's claims for reserved water rights for the monument with two exceptions. First, a reserved water right for recreation boating was denied (secondary purpose), and that ruling was not appealed. Secondly, the court remanded to the water court the issue of whether one of the primary purposes of the reservation was the preservation of the native fishery resource; and, if "yes", the amount of instream flows necessary for that purpose.

The monument provides essential habitat for the endangered Colorado squawfish and humpback chub. The major of only two known spawning areas for Colorado squawfish is situated in the Yampa River in the monument. A humpback chub population in the Yampa may be the only genetically pure population remaining in the upper Colorado River Basin.

The NPS filed with the court our arguments regarding the history of the monument and the legal basis by which reserved water rights were claimed for various purposes, including water for the endangered Colorado squawfish and humpback chub. Additionally, we provided a quantification of the minimum river flow requirements necessary to fulfill reservation purposes. These were supported by scientific studies conducted over a three to four year period.

On March 14, 1985, District Judge Hume (District Court, Water Division No. 6) granted a motion for summary judgement dismissing the NPS application for instream flow rights for the Yampa River (Case No. W-85). The ruling provided that the monument would be entitled to reserved water rights only for those purposes stated in the original establishment of the monument (i.e. for dinosaur bones in 1915). That ruling was regarded by NPS, the USDI, the U.S. Solicitor's Office, and regional U.S. Department of Justice office as poorly reasoned and narrowly held.

The Washington office of the U.S. Department of Justice decided not to appeal the ruling. Therefore, Judge Hume's ruling denying our application for instream minimum flow rights stands. With the

failure to appeal, the NPS apparently has no standing to reissue the instream flow claim.

The "Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin" identifies the Yampa River as the highest priority for purchase of water rights for instream flows. Negotiations are currently underway to purchase several water rights in the Yampa River, one (Juniper-Cross Mountain) of which may control 75% of the Yampa River's flow. Local support for sale of these water rights is steadily increasing. Similar negotiations are also underway for purchase of water rights from the Little Snake River, the primary tributary to the Yampa. A combination of federal and State funds, Nature Conservancy monies and other private funds will be used for the purchases.

The National Park Service desires to secure, through purchase or adjudication, sufficient river flows to protect the unique values of Dinosaur National Monument.

Water rights have been perfected for several upland water resources. Following a full inventory of such water resources (see below), it may be appropriate to seek additional water rights for other water sources in both Colorado and Utah.

d. UPLAND WATER RESOURCES

Upland water resources include all waters except the Green and Yampa Rivers. These are spring, seeps, perennial streams, intermittent streams and stock ponds. An adequate baseline inventory should be compiled for these resources. The inventory should consider location, yield or capacity, associated vegetation, temperature and various water quality parameters.

2. AIR RESOURCES AND RELATED ISSUES

a. AMBIENT SOUND MONITORING

An ambient sound monitoring program was initiated in 1989. Recording monitors were operated for one year each on West Cactus Flat (1989-1990), Harpers Corner (1990-1991) and near the Dinosaur Quarry (1992-1993). West Cactus Flat was chosen to represent a backcountry site with light visitor use and minimal vehicle intrusion. Harpers Corner was chosen to represent a site which receives seasonal traffic. The Quarry area site was selected to represent an area which experiences persistent and high visitor use.

Results of the monitoring reveal very low background sound levels at the sampling sites. The L90 averages for all three sites ranged from 22 to 25 db. Sound levels often were as low as 20 db, the level expected in a high quality sound studio. In limited sampling with specialized microphones, background sound levels were as low as 7 db in the frequency range audible to humans.

Data from the ambient sound monitoring program will be important in defining solitude within the park and in assessing the impact on solitude from proposed developments outside the monument.

b. AIR QUALITY

Dinosaur National Monument is designated a Class II floor area under the 1977 Clean Air Act amendments. Monument lands within Colorado have been designated as a Class 1 area by the State of Colorado. Although not as comprehensive as the federal Class I standard, a Class 1 designation is the most restrictive State designation. At the present time, all lands adjacent to the Monument are also designated as Class II.

Air quality and air quality related values (AQRVs) are regarded as high at Dinosaur National Monument, but, with the exception of visibility, few quantitative data are available.

Particulate data was collected with a high volume dichotomous particulate sampler for about 2 years during the early 1980s. Results of that monitoring indicate a fine sulfate to fine mass ratio of 32 percent. These and other data are summarized in Air Quality in the National Parks (Energy and Resource Consultants, Inc. 1988).

Data from the nearest NADP sites indicate the possibility of abnormally low pH precipitation in the region which includes Dinosaur National Monument. Increasing coal development and use in the region suggests further deterioration may be expected, with potential adverse impacts on biotic and abiotic systems of Dinosaur National Monument.

Although the Quarry site is protected within the Visitor Center, most of the vertebrate fossil resource is scattered in the back country. Fossil bone is commonly thought of as having "turned to stone", but this is not the case. Schopf (1975) has shown that fossilized bone is essentially unaltered, and this has been confirmed at Dinosaur. The mineral apatite, which is present in the fossils, is sensitive to acid. We are aware of no studies which examine the acid deposition impact on fossil vertebrate remains.

The energy-rich Uintah, Rangely, and Piceance Basins, which lie southwest, south and southeast of Dinosaur, have undergone significant growth and development since the mid-1970's. Oil and gas exploration and development, synthetic fuel production, coal production, and coal fired power plants are the major energy-related activities near the monument.

Development of abundant energy resources in the vicinity of the monument may threaten the integrity of the pristine air quality of the region. Associated with all regional developments are air quality impacts resulting from emissions and fugitive dust, as well as secondary impacts due to increased population of local communities and an expected rise in local visitation and use of monument facilities. Secondary effects may include adverse impacts on the native vegetation, wildlife, soils, and water quality of the monument, which together or in concert may have far-reaching impacts on ecosystem stability and function. Acid deposition may have adverse impacts on both biotic and abiotic resources.

While the most significant threats to the air quality of Dinosaur National Monument are expected to come from the south and west, the direction of the prevailing winds, irregular regional topography creates local wind patterns that may deviate from the prevailing standard and may concentrate pollutants in canyons and valleys. Potential air quality impacts of the Craig Power Plant near Craig, Colorado, the Hayden Power Plant near Hayden, Colorado, and the Jim Bridger Power Plant near Evanston, Wyoming are unknown and need to be examined.

Sulfur oxides and nitrogen oxides are two of the primary effluent components of fossil-fuel combustion, and have been shown to cause significant plant injury (Kozlowski 1980.) The scientific literature abounds with case studies of organismal and community damage resulting from both short-term exposure to high pollutant concentrations and longer-term exposure to lower concentrations. Damage thresholds to many arid and semi-arid region plants, a large number of which occur in Dinosaur National Monument, have been shown to be extremely low and within the expected levels found downwind of modern coal-fired power plants (EPA 1977.) Hill et al. (1974) found that the most sensitive species were mostly annual herbs and some grasses and shrubs, e.g. globemallow (Sphaealcae sp,) Indian ricegrass (Oryzopis hymenoides,) and Utah serviceberry (Amelanchier utahensis). Some of the coniferous trees that occur at high elevations in the southwest have also been shown to be extremely sensitive to SO_2 and NO_2 concentrations. In Dinosaur these include Douglas-fir (Pseudotsuga menziessi) and Ponderosa Pine (Pinus ponderosa.) Biological injury from gaseous pollutants is dependent upon many factors, including the gas exchange capacity of the receptor plant, i.e. the ability of the plant to uptake the

pollutant and incorporate it into its tissues. The adaptations to a hot, dry environment protect most arid region plants from excessive respiration rates (which would encourage pollutant uptake) but periods of increased moisture availability during the growing season will encourage respiration and susceptibility to SO_2 or NO_2 damage. This is particularly true for short-lived annuals that confine most of their growth to wetter periods in the spring or late summer.

Lichens, when moist, absorb gases over their entire surface and are extremely sensitive to injury induced by SO_2 pollution. As such, they can be used as bioindicators of ecosystem air pollution stress. In microbiotic soil associations with various algal species, lichens play a crucial role in the stability and health of arid region shrub and grasslands such as those found throughout Dinosaur National Monument.

Air pollution-induced stresses are aggregated in community dynamics since the structure and stability of an ecosystem may depend on one or more critical species. Imbalances and simplification of community structure that typify pollution-stressed ecosystems lead to a decline in standing biomass and a reduction in the size of the nutrient pool of the system. Since the potential of any such system to support life depends heavily upon the nutrient pool available to it from recycling and breakdown of primary minerals, this has broad implications for ecosystem health and recovery (Woodwell 1970). These threats are especially critical at NPS units such as Dinosaur National Monument which are mandated to preserve and protect natural ecosystems in an unimpaired condition.

The potential exists for serious impacts to monument resources and values from acid deposition. Dinosaur already receives some of the most acidic deposition (pH of less than 5.0) in the intermountain west (Lippincott et al. 1982). Existing and/or potential acid rain impacts have not been identified or quantified. The vulnerability of Dinosaur's biotic and abiotic systems to impacts from acid deposition has not been determined. Of particular concern are the fossil resources. Calcium compounds (primarily CaO) comprise a significant portion of fossil bones at Dinosaur (Bischoff 1982). Although the fossil resources within the Quarry building are somewhat protected, fossil remains exposed in other parts of the park may be quite vulnerable to degradation from acid deposition.

There are some indications that relatively few energy and energy related developments upstream in Dinosaur's airshed will use up most, if not all, of the Class II PSD increment SO_2. Construction and/or operation of other proposed energy developments could reach or exceed the allowable increment. The Colorado Class 1 PSD increment for SO_2 may be exceeded in the near future.

Ongoing data collection related to air quality and AQRVs is limited to collection of meteorological data via an automated met station, NOAA weather and fire weather.

Currently there are no management actions to determine compliance with federal and state SO_2, NO_2, suspended particulate, or other air quality standards. There are no actions to ascertain baseline information on air quality related values within Dinosaur. There are no actions to determine existing vegetative, soil, or water quality conditions as they relate to air quality impairment. There are no actions to identify acid deposition conditions and vulnerabilities in the immediate area. As discussed above many plants found at Dinosaur are known to be sensitive to varying amounts of SO_2, NO_2, and other pollutants commonly generated by fossil fuel combustion. No research has ever been conducted in the park, however, on air pollution sensitivities, threshold toxicities, or even inventories of what sensitive plants exist here. No effort has been made as yet to determine community and ecosystem impacts of air pollution at Dinosaur.

Additional proposed research and monitoring activities include completionof the lichen inventory, elemental analysis of lichens collected at reference sites, identification and monitoring of other air pollution sensitive species, (monitoring of cultural materials -e.g. rock art) and operation of a NADP or NDDN site. Other air quality related management efforts include reviewing energy exploration and development proposals to assess potential air quality impacts.

c. VISIBILITY

Visibility monitoring, using multiwave teleradiometers and 35mm camera was conducted from 1977 through 1991. The average summer 10th percentile and 90th percentile visible range from Dinosaur are 105 and 277 kilometers respectively (about 65 and 172 miles). These and other data are summarized in Air Quality in the National Parks (Energy and Resource Consultants, Inc. 1988). WASO-AIR has determined that an adequate baseline exists for visibility. Monitoring may be renewed if significant developments are anticipated to further degrade visibility.

3. RESOURCE USES

a. GRAZING MANAGEMENT

The Presidential Proclamation which expanded Dinosaur in 1938 was silent on the issue of grazing by domestic livestock. The administrative history associated with that expansion, however, clearly envisioned the eventual removal of domestic livestock. An Act of Congress in 1960 (P.L. 86-729) delineated an orderly phase-out of grazing in the monument. Dates of termination of the remaining grazing are dependent on (1) the lifetime of the original permittee and dependent heirs, (2) sale or lease of certain baselands, and/or (3) purchase of inholdings by the NPS.

The current maximum allowable use is 2,357 AUMs (animal unit months) on 11 allotments totaling 80,168 acres. All or portions of grazing privileges on 13 allotments (52,330 acres; 2,967 AUMs) were terminated in 1985. Of the 9 remaining permittees, all or a portion of the grazing privileges for 6 permittees are appurtenant to inholdings; approximately 1,100 AUMs can be terminated only after purchase of the inholdings by the NPS. All or a portion of the grazing privileges for 6 permittees are appurtenant to base lands outside the park; approximately 1,260 AUMs will be terminated when (1) base lands are sold or leased or (2) after the lifetime of the 1960 permittee and any heirs dependent on the land in 1960. Table 1. shows the current distribution of grazing in the monument.

After termination of grazing within the monument, grazing will still continue on contiguous BLM and private lands. The absence of suitable fences and presence of stock ponds does not inhibit and may actually induce trespass of livestock onto monument lands. Significant trespass problems have been encountered in several locations (e.g. Wild Mountain, Iron Mine Basin). Unless the monument chooses to tolerate significant trespass grazing, some means of controlling trespass must be developed.

Stock ponds are scattered throughout Dinosaur National Monument. Virtually all are small, earth-fill structures. Those ponds within one mile of the boundary have the greatest potential for inducing trespass livestock from outside the monument. In several instances, BLM has authorized construction and/or repair of reservoirs immediately adjacent to the park boundary. These also contribute to trespass problems.

Dinosaur's boundary exceeds 150 miles in length. Less than 50 miles of the boundary is currently fenced; much of that is in disrepair. Fencing projects in 1992 and 1993 have been focused on constructing boundary fences in areas of repeated livestock trespass.

Grazing by domestic livestock creates adverse impacts on monument resources and values such as wildlife, vegetation, soils, cultural sites and recreation.

Differences in species composition, diversity and abundance exist between grazed and ungrazed vegetative communities. Non-native species such as cheat grass are more prevalent on heavily grazed ranges. The proliferation of sagebrush may be attributed in part to grazing (and to the past exclusion of fire). There may be influences on sensitive and rare plant species.

Table 1. Summary of current grazing privileges, Dinosaur National Monument, 1 January 1994.

Permittee	Allotment	# AUMs	Location of base lands
Walker	Big Joe	65	outside DINO
	Zenobia	342	inside DINO
J. Hacking	Blue Mtn	98	inside DINO
Mantle	Blue Mtn	953	inside and outside
Murray	Murray	215	outside DINO
Staley	Island Park	14	inside DINO
R. Hacking	Wild Mtn	34	inside DINO
Massey	Massey	41	outside DINO
Chew	Harpers Corner Docs Valley & Green River	511	both inside and outside DINO
Wilkins	HC, DV & GR	84	outside DINO
	Total	2,357	

Bighorn sheep and elk are seldom observed on ranges used extensively by domestic livestock. These effects appear to be abating as grazing in reduced or terminated in important elk and bighorn sheep range. Effects on small mammal and bird populations have not been studied in Dinosaur.

There appears to be a marked difference in the amount and distribution of microbiotic soil cover between grazed and ungrazed areas. Anderson et al. (1982a, 1982b) noted that both the total cryptogamic cover and the number of cryptogamic species significantly decreased under grazing pressure. The subsequent reduction in soil stability rendered those soils more vulnerable to water and wind erosion. Anderson et al. (1982a) suggested that the reduction in soil stability must also result in a decline in carrying capacity on those ranges. Soil compaction, independent of the loss of microbiotic soil crusts, would reduce infiltration and increase runoff (and thus increase erosion). Other effects on soils or soil characteristics are probable, but undocumented, in Dinosaur.

It is quite probable that domestic livestock have had significant detrimental effects on cultural resources, particularly archeological sites. Substrates under overhangs or in caves in the canyon

country, such as those commonly used by Fremont and older cultures, are often severely compacted and littered with manure. In several instances, artifacts such as manos and metates have been observed on the surface in these impacted areas. More fragile types of artifacts, such as corncobs, potsherds and arrowheads, may have been destroyed or displaced. Archeological studies have not been conducted in Dinosaur to determine the extent or significance of these impacts.

Conflicts between grazing operations and recreational uses exist in Dinosaur. Of greatest visibility are the effects of grazing in river campgrounds, i.e. losses of vegetation and occasionally copious amounts of manure. Complaints by river boaters are common. The effects of grazing on river and other recreation in Dinosaur have not been quantified.

Current management actions include evaluating permit applications, issuing permits, checking permit compliance, conducting cursory range evaluations, limited boundary fencing, and coordinating actions with the Bureau of Land Management on contiguous allotments. Coordination with the BLM (2 Districts, 4 Resource Areas), particularly regarding seasons of use, stocking levels and percentages of total use, is critical since all but one allotment are contiguous with BLM allotments.

Dinosaur's Management Objectives direct that grazing be managed so as to mitigate its adverse effects upon natural ecosystems.

b. RIVER MANAGEMENT

Dinosaur conducts a complex river management program pursuant to the approved River Management Plan. This plan was subjected to extensive public review prior to adoption and implementation in 1979. The program is intended to minimize the impact of river boaters on river and riparian ecosystems as well as provide a variety of high quality recreation opportunities. It includes commercial and non-commercial permitting systems, campground scheduling, campground impact monitoring, human waste disposal and associated resource management activities.

Prior to implementation of the current plan, river use was limited only by campground availability, an annual user-day limit (40,000 user days), and a maximum group size of 50 persons. Use tended to be concentrated on (and immediately before) weekends and holidays. Campground areas were reduced to bare soil, particularly near the centers of the sites. Trampling and loss of vegetation was evident a considerable distance (depending on the campsite) from the center of the camp. Ecological research (Jerry 1977, Tierney 1979, McBrayer 1980) was conducted to document the impacts of river

boaters on river campgrounds. Tierney (1979) noted that the impact of large groups was disproportionately high. Large groups spread out more than small groups. After the preferred sleeping sites near the center of most camps were occupied, other boaters from large groups were forced to select less amenable sites farther from the camp center. Since the vegetation types in campground areas are quite intolerant of trampling, a few large groups could cause noticeable impacts in a given camp. Tierney (1979) pointed out that the same number of people, accommodated in smaller groups, would cause significantly less impact since most of their activities would be concentrated near the center of camps.

With implementation of the River Management Plan, maximum group size was reduced to 25 persons, launches were evenly-distributed throughout the week and season, and (as before) campgrounds were assigned to each river party. Although the total allowable number of user days is greater than that allowed prior to plan implementation, the impacts appear noticeably less. Ground cover near the centers of campsites is still minimal or absent but most of the secondary or tertiary sleeping sites are revegetation naturally. Management has determined that bare ground "sacrifice areas" at the centers of campsites are acceptable because there appear to be no other reasonable alternatives to rectify the situation.

Picnic tables, fire pans and/or fire grates, and pit toilets were provided at most river camps. Dinosaur's Wilderness Proposal made specific provisions for retention of these facilities in proposed wilderness. The facilities were intended (1) for visitor convenience and (2) resource protection. It was believed that the facilities, by providing a focus point for visitor activities, would concentrate those activities and thus minimize impacts in adjacent area. The facilities, particularly the fire pans/grates and picnic tables, indeed concentrated visitor use. In some camps, however, appropriate sites for pit toilets were quite limited. Toilets usually filled and had to be relocated about every three years. All campground facilities (picnic tables, fire grates and pit toilets) were removed in 1989 and 1990. A carry-out system for human waste was initiated in 1990.

With two rivers (and their boaters) converging in the heart of the monument and with the need to protect a delicate riparian ecosystem, administration of the river management system is a complex and time-consuming operation. Six hundred launches are evenly divided between 11 concessionaires and 2,500 to 3,000 non-commercial applicants during the main summer season. Four to six launches are permitted each day; campgrounds are assigned to restrict most impacts to selected locations. One launch per day, without assigned campgrounds, is permitted throughout the low use season. Further complicating the administration of the river program is the

provision for 1-day use in Split Mountain with a permitting system which parallels the multi-day permit system. Considerable scheduling difficulties arise in apportioning use among over 30 river camps. Total annual use is about 35,000 boater days.

Field work involves concession evaluations, monitoring of impacts in the camps and limited relocation/replacement of camps.

Staffing for river use management is insufficient to ensure optimum resource protection. Demands for field activities - campground monitoring, research support, other resource management operations, patrols for illegal users, etc. - have also increased significantly. Monitoring of human impacts in the river corridor has largely been foregone for the past several years.

Major issues which will be considered in any future revisions to the River Management Plan include user limits such as total use levels, permit lottery systems, a "user day pool", distribution of use between commercial and non-commercial users, and number of launches per day by season; the number, location and condition of campsites (including sandbars) and facilities; revision of sanatationa and equipment requirements; and impacts of such use on natural systems (e.g. Canada geese nesting, bighorn sheep, campground and trail erosion, etc.).

b. ECHO PARK CAMPGROUND

Echo Park, located at the confluence of the Green and Yampa River, is an extremely popular camping area. The campground, however, is being eroded away by the Green River. The entire campground may eventually be reclaimed by the river.

At least since 1970, monument personnel have been concerned about erosion at the camp area. Years with little erosion are interspersed with years of intense erosion. During periods of erosion, large sections of bank have caved into the river together with the boxelder and cottonwood trees which shaded campsites, In the 1982 season, one campsite was lost to the river and the bank retreated inland an average of six feet along the entire campground. It is probable that more was lost; monitoring did not start until well after peak flow. The location of the ranger cabin prior to 1977 has been entirely recovered by the river (the cabin was moved further from the bank in 1977). The old cabin was removed in 1983 and a new cabin was built slightly further from the actively eroding bank. Since monitoring began in 1982, the river bank in the campground area has receded by up to 150 feet. The campground had been reduced from about 20 sites to 10 sites in 1992.

In 1984, record flows from the Yampa River and record releases from Flaming Gorge Dam combined to flood much of Echo Park. The new cabin stood as an island as all old flood channels were filled with water. Cottonwood regeneration was abundant after flood waters receded but virtually none of the seedlings survived for more than two years. Most of Echo Park's cottonwoods will eventually be lost to the river. No recruitment of cottonwoods or boxelders has occurred in the camp area for at least the last twenty years. Unless the new cabin in moved, it may also be lost to the river within the next few years.

Additional campsite losses in 1991 prompted the emergency establishment of several temporary campsites along and in the boxelder stands which parallel the river in the southern portion of Echo Park. Continued erosion led to the decision in 1993 to convert all remaining sites in the original campground to "walk-in" sites. A parking area was established near the cabin and the number of sites in the boxelder grove was increased to provide for at least limited visitor camping. These campsites are likely to have disproportionately high resource impacts. Planning efforts are underway to relocate all campsites to another area near the southeast portion of Echo Park. Since this area is an old field, no impacts are anticipated to archeological resources. The area also has sufficient elevation to remain uninundated by river flows of up to 40,000 cfs. Floodplain studies indicate that a 100-year flood from Pool Creek Canyon might inundate the proposed site but water velocity would be low. All other potential sites in Echo Park have the likelihood of much more significant resource impacts.

The recommended actions are to (1) continue monitoring of bank erosion and (2) relocate the campground and cabin as soon as funds become available.

c. MINING AND MINERALS

Presidential Proclamation No. 2290 expanded Dinosaur National Monument to include the Green and Yampa River canyons and adjacent areas, subject to prior existing rights. Federal lands within this reservation were withdrawn from mineral entry. There remained, however, an estimated 2,500 unpatented mining claims within the boundaries of the park. Section 8 of Public Law 94-429 (National Park System mining legislation) provided that all mining claim locations under the Mining Law of 1872 which lie within the boundaries of units of the National Park System must be recorded with the Secretary of the Interior within 1 year after the effective date of the Act (September 28, 1976). Any claims not so recorded within the specified time frame would be presumed to be abandoned and would be void. No claims were recorded with the National Park Service during the specified time period. Therefore,

all unpatented mining claims on federal lands within Dinosaur National Monument were voided.

Within the monument there are 3,945.96 acres of non-federal mineral interest (925.07 acres in Colorado, 3,020.89 acres in Utah). That interest ranges from all minerals to certain identified minerals to oil and gas only. Of these lands, the surface of 2,564.91 acres is also in non-federal ownership. A split estate (federal surface, non-federal minerals) occurs on 1,381.05 acres. The largest holder of non-federal minerals is the State of Utah (2,760.71 acres). Excluded from these figures are non-federal mineral interest in lands under the Deerlodge road right-of-way and NPS scenic easement areas. Descriptions of individual tracts and non-federal mineral reservations are available in Mineral Title Reports at the park.

While recognizing the valid existing rights of subsurface land owners, legislation and proclamations establishing Dinosaur National Monument did not authorize the exploration and extraction of federal or non-federal oil, gas, or other mineral resources within the monument boundary. Oil, gas, and other mineral development within the monument are incompatible activities because of their impact upon the scenic, natural and cultural resources and the visitor experience. Impacts upon the monument's natural environment would include removal of vegetation, erosion of soil, and degradation of air in the immediate area and water quality in adjacent stream drainages. Impacts upon the monument's cultural resources would include the disruption or destruction of archeological sites. This would result in mixing of objects so that the value of their spatial relationships would be lost to science. Adverse effects on visitors would include the sight of derricks, pumps, sludge pits, tanks, access roads and the sound of equipment, all of which would intrude on the natural scene.

There are no known mineral resources within the monument that would be profitable to develop at the present time. Nonetheless, nearly all of the lands with State of Utah mineral interest have been leased for oil and gas exploration.

There have been no recent attempts to engage in any mineral exploration or development of non-federal minerals within the monument. Any such exploration or development of non-federal oil and gas resources would have to be conducted pursuant to regulations promulgated in 36 CFR 9(b). No regulations exist to govern exploration and development of any other mineral interests. If the owner of non-federal minerals (other than oil and gas) indicated intent to develop those potential resources, the monument would request a proposed plan of operations, prepare an Environmental Assessment, and then either permit the activity under a Special Use Permit or deny such a permit. Denial of a permit may be regarded

as preliminary to a taking of the non-federal mineral interest.

Virtually all of the BLM lands adjacent to the park (including rights-of-way) are available for mineral entry. Most of such lands are already leased for oil and gas exploration. Exploration and/or development of such resources may result in significant impacts to park resources and values. We are continuing to work with the BLM in their planning process to protect monument resources and values from such impacts. That protection make take the form of withdrawals from entry, stipulations on future leases or conditions of permits.

4. OTHER LAND USE ISSUES

a. NON-FEDERAL LANDS

There are 25 private and public inholding parcels (14 ownerships) within the authorized boundary of the monument. The largest inholder is the State of Utah with 1,8009.68 acres administered by the Division of State Lands and Forestry and 155.23 acres administered by the Division of Wildlife Resources. A total of 3.545.45 acres remain in private ownership; the single largest ownership controls 1,461.12 acres.

The monument's Land Protection Plan identifies the individual inholding tracts and associated resource issues. Agency and park policy direct (1) opportunity purchases of inholdings and (2) adoption of measures necessary to prevent uses which would damage park resources and values. With an increasing understanding of sensitive resources and increasing land use problems associated with inholdings, it would be appropriate to review and revise the Land Protection Plan within the next few years.

b. BACKCOUNTRY/WILDERNESS MANAGEMENT

Nearly 204,000 of the monument's 211,000 acres are included in the "Natural Zone" (SFM, 1990). Of these, about 188,000 acres have been proposed as wilderness and are presently managed to protect wilderness values.

Dinosaur's Backcountry Management Plan was completed in 1984. It identified certain sensitive natural and cultural resources, delineated areas which should be seasonally closed to visitor use, and established public use limits (number in party, camping restrictions, etc.). With better baseline inventories on sensitive resources and values (e.g. solitude) and with an increasing interest in diverse and sometimes conflicting backcountry uses, some changes to the plan are appropriate. Pending further planning

actions or enactment of wilderness legislation, management will assess each new or significantly increased use on a case-by-case basis.

c. BACKCOUNTRY ROADS

There are numerous backcountry roads in Dinosaur. Most are "two-track" spurs from established park roads to certain points. They vary in length from well less than a mile to about 3 or 4 miles. Some are identified for retention in various versions of maps of proposed wilderness; others are proposed on various maps for removal. Most of these roads were initially associated with grazing operations. The present use of these roads ranges from none (abandoned) to minimal public use. Many of the roads provide access for important resource management, monitoring and research efforts.

Monument staff needs to make a systematic assessment of the needs for backcountry roads, resource impacts associated with their retention, resource management impacts and costs associated with removal, and compatibility of retention or removal with other park and wilderness management policies. Roads which will then be removed should be, as feasible, obliterated and rehabilitated. Those retained should be managed so as to minimize impacts of their use on resources and resource values. Proposed wilderness maps should be amended to reflect these decisions. Actions pursuant to RS 2477 may complicate plans to close and rehabilitate some old roads.

d. BOUNDARY ISSUES

Dinosaur National Monument is shaped like an inverted "T". The actual boundary follows artificial lines and is often ineffective in protecting park resources and values. In some locations, the NPS owns lands outside the authorized boundary; these were acquired in the process of purchasing inholdings.

Problems associated with the present alignment of the park boundary include grazing trespass, hunter trespass, impacts due to energy-related exploration and development, and impacts attributable to other land management practices (e.g. sagebrush control, insect control, etc.). There is potential for boundary adjustments at two scales. On a limited scale, minor boundary adjustments might simplify management for both the National Park Service and the Bureau of Land Management. On a broader scale, more significant boundary adjustments which would better protect park resources and values should be investigated. These adjustments should generally encompass local watersheds and viewsheds and should also give consideration to known paleontological resources when they are

immediately adjacent to park resources and appear to be of notable significance.

e. ACCESS ISSUES

In the Act of September 8, 1960 (P.L. 86-729), the Secretary of the Interior was authorized to select entrance roads to the monument from U.S. Highway 40. The act specified the average number of acres per mile that would be permitted for the rights-of-way and scenic easements. Two issues are of immediate importance in providing access to the monument: (1) realignments around earth-slides on the Harpers Corner road and (2) formal establishment of the Echo Park road corridor from Harpers Corner road to the monument boundary. If Secretarial selection is appropriate, such selection could be implemented by describing the roadway and adjacent scenic easement and publishing the notice of selection and description in the Federal Register. If these additional selected lands were made part of the monument, future mineral leasing would be precluded from the surface of the selected lands and continued access to the monument would be ensured.

There are many access routes to other portions of the monument boundary which have been established across federal and private lands through a long history of use. These routes provide access for visitors and for management of park lands and resources. In recent years, there has been a marked tendency to attempt to close roads or otherwise restrict access, particularly by private owners. It is the intent of Dinosaur National Monument to pursue, by whatever means are available, continued access to various portions of the monument boundary. Such access is necessary for the proper use, protection and management of park resources and values. Actions pursuant to RS 2477 may ensure access across non-NPS lands to the park boundary.

G. GEOGRAPHIC INFORMATION SYSTEM

A. HARDWARE AND SOFTWARE

Though every division in Dinosaur has access to and uses computers, Dinosaur presently has no hardware capable of running either a PC DOS version GIS (such as ARC/INFO) or a UNIX based system (GRASS). Likewise, the park does not own any type of GIS software.

B. PERSONNEL

Though Dinosaur has identified a computer specialist as a top

priority for increased permanent staffing, the park does not currently employee an ADP manager. Therefore, a UNIX based GIS system could not be effectively maintained. A simpler, PC DOS based GIS system could be maintained in certain divisions with present staff.

C. DIGITIZED DATA

Because Dinosaur has not utilized GIS technology as part of its normal operations, the park presently has little digitized data. Most of the park's data is in tabular or paper form which will need to be transferred to stable base overlays before it can be digitized. Fire Management estimates that 100% of its present data is on paper maps. Biological resource management estimates that 20% of its data is already digitized, 70% is in tabular form and 10% is on mylar overlays. Paleontological resource management estimates that 100% of its data is in tabular and paper map form, as does cultural resource management. Visitor protection has 100% of its data in tabular form. A full 100% of visitor use data has not been collected as yet.

Some basic GIS components, such as topographic features, have been digitized (Digital Elevation Model of DEM data) by other agencies and can be purchased for many areas in Dinosaur. This is data digitized from USGS 7.5 min. quads. (See Appendix ____).

Very Little Digital Line Graph (DLG) data is available for DINO (See Appendix _____).

No National Wetlands Inventory (NWI) data is available for Dinosaur (See Appendix _____). However, a pending Rocky Mountain Regional Office proposal would split the cost of generating this data from 1:620000 color infra red photography with USFWS through a program coming out of the NPS Washington Branch of Water Resources.

Vegetation data is available from the NPS Washington Office (WASO) in the form of remote sensing images. Also, Landsat images exist for the entire park, though at this time it is not known if this data is available for purchase.

Digitized data is also available from surrounding BLM districts. This data includes themes such as soils, archeological sites, vegetation, mineral resources, etc. BLM data also includes resources on BOREC, State and some lands within Dinosaur.

IV. OVERVIEW OF CURRENT NATURAL RESOURCES PROGRAM AND NEEDS

The overview section is structured to address both program administration and staffing and resource management programs. The purpose of this division is to highlight both the critical shortage of professional staff and the basic activities which should be conducted by those staff.

The additional staff are critical if we are to conduct basic resource management activities at the minimally acceptable level. Without additional staff and funding even some programs which are prescribed by legislation, policy and NPS directives (e.g. endangered species monitoring) will be foregone.

Only the highest priority natural resource programs are discussed in this overview. Lower priority programs may be conducted at minimal levels coincident with more important programs or may be foregone indefinitely.

For the purposes of this plan, reference to natural resource management as a function relates to the management, monitoring, research, etc. of flora, fauna, air, water, soils, and natural processes such as fire, hydrology and geomorphology. Reference to paleontological resource management as a function relates to the management, monitoring, research, etc. of fossil resources and museum specimens. Natural resource management programs include activities conducted by both natural and paleontological functions.

A. PROGRAM ADMINISTRATION AND STAFFING

1. NATURAL RESOURCES

Dinosaur's natural resource management function is staffed with only one base-funded permanent Resource Management Specialist (RMS) and a few seasonals supported by project funds. The RMS position is almost entirely consumed with program administration activities: administering a wide variety of resource management programs such as grazing by domestic livestock, endangered species programs, wildlife management, vegetation management, etc.; identifying research needs and coordinating research efforts; supervising permanent and seasonal positions (see fire management below); identifying and assessing internal and external threats; coordinating activities with other federal and State agencies; planning; environmental compliance (internal and external); preparing

necessary reports; participating in national and regional task forces; and providing training at national and regional levels. These activities are described in greater detail under Program Administration in the STATUS section and in project statement DINO-N-010.001.

The involvement in these programs is virtually all of a management or administrative nature; there is little time for any field activities. For many activities, there is time only for the most basic coordination or management. All of the RMS effort is committed to the highest priority portions of various resource management programs and those special projects needed by park management. This level of staffing is insufficient to meet basic program needs as defined by legislation, policy and directives. Many programs are foregone because of a lack of staff time and support costs.

All of the resource management field activities conducted for the past several years have been (1) funded by specific project funds (e.g. NRPP for peregrine falcon recovery efforts, WASO-WRD funds for riparian rehabilitation data collection) or (2) conducted through volunteer time and professional services donated by other agencies (e.g. insect and small mammal baseline inventories). Many projects funded or partially funded by special accounts have been effected only because of additional volunteer or SCA time (e.g. peregrine falcon recovery efforts, herptile baseline inventory). No base funds are available for critical operational needs such as monitoring authorized and trespass grazing, monitoring rare and non-native plants, inventorying upland water resources and wetlands, monitoring wildlife populations, supporting other agency research on endangered species, and the like.

There is an immediate need for 3.0 additional FTEs for permanent staff and a minimum of 2.0 FTEs for seasonal staff. The permanent FTEs are identified in DINO-N-021.101 (staffing). Seasonal FTEs are identified in other high priority project statements such as DINO-N-632.001-.007 (grazing management), DINO-N-340.001-.003 (rare plant monitoring), DINO-N-461.001 (peregrine falcon recovery program). An additional 1.0 FTE in seasonal services are needed for boundary fence repair.

This increased staffing is related to a number of servicewide issues, particularly N02, N03, N19 AND N20. These staff will be committed to high priority natural resource activities such as grazing management, endangered species management, rare plant monitoring and clearances, monitoring external threats posed by activities on adjacent lands (e.g. oil and gas exploration), monitoring visitor impacts on various resources and resource values, preparing and/or reviewing NPS and other agency environmen-

tal documents, resource management planning and interagency coordination. The distribution of these needed FTEs is:

GS-401-11 Biologist (Vegetation)	1.0 FTE
GS-401-09 Biologist (Wildlife)	1.0 FTE
GS-303-05 Clerk	1.0 FTE
GS-404-05 Biological Technicians	2.0 FTE

With the addition of the FTEs and funds for these positions, most of the high priority resource management programs could be implemented at the minimum professional level. Additional funding would still be needed for special initiatives and research projects.

A subset of the natural resource management function, fire management is staffed with a permanent Fire Management Officer, Fire Program Clerk and several seasonal employees. All these are funded by FIREPRO and are committed nearly full time to basic fire management planning and operations. Other fire-related activities (e.g. fire effects monitoring) are funded on a year-to-year basis by FIREPRO. The fire management program is supervised by the Fire Management Officer

2. PALEONTOLOGIC/GEOLOGIC RESOURCES

Dinosaur's paleontological resource management function is staffed with three permanent base-funded positions, one paleontologist (GS-1350-11) and two museum technician fossil preparators (GS-1016-09). Erratically there are seasonal positions supported by project funds and volunteers.

The paleontologist position is almost entirely consumed with program administrative duties: administering a variety of resource management programs such as paleontological resources management, geological resources management, conducting research, etc.; preparing and overseeing budgets; identifying research needs, recruiting researchers, co-ordinating research efforts among park staff, outside researchers, and contract researchers; supervising two permanent preparators and seasonals and volunteers; serving as the park's curator; identifying internal and external threats, and developing and implementing mitigation programs; coordinating activities with other local, state, and federal agencies and with college, universities, and museums; preparing reports, manuscripts, and technical presentations of activities for professional meetings; participating in regional and national task forces and committees; serving on committees of professional societies and on advisory boards for other state and federal parks; and providing

training at regional and national levels and for other state and federal agencies and parks.

The fossil preparator positions' primary duties involve the excavation, collection, preparation and conservation of fossil specimens; documenting excavations (quarry maps, photographic and video recording, making field observations in excavation notebooks, etc.); surveying and inventorying localities; preparing and maintaining locality files; recruiting, training, and supervising volunteers; planning excavation activities and purchasing supplies for field work and lab activities; identifying threats to specimens being excavated; assisting outside and contractors in field work; preparing specimens for outside researchers; assisting and providing training for other state local and federal agencies and museums.

Many of the paleontological resource management field activities conducted over the past several years have been (1) funded by specific project funds (e.g. NRPP for Morrison Inventory and Morrison Geology Study), (2) conducted through volunteer time and professional services donated by other individuals (diagnosis of Dinosaur Quarry, Morrison salamanders and frogs, etc.), or (3) were conducted by park staff, but with significant assistance from volunteers and non-agency funding (Earthwatch funding for microvertebrate screenwashing, various dinosaur excavations). However, base funds and staffing are insufficient for other critical operational needs such as establishing a paleontological resources monitoring program, conducting cyclic prospecting of known fossiliferous areas, excavating all significant fossil localities threatened by erosion, etc.

Limited geological resources management activities are conducted by the paleontological staff. These are limited to relatively simple observations usually made during paleontological excavations or inventories. Although more comprehensive and detailed geological baseline data needs have been identified, monument staff does not have the requisite expertise to gather such data.

In addition to its heavy workload in paleontological and geological resources management, the paleontological program is also responsible for management of the museum collection program. For the paleontologist this includes preparing reports and budgets, identifying threats and equipment and storage space needs, preparing collections related plans; administering accessioning and cataloging activities, coordinating loans, accessioning, and cataloging with all staff and outside and contract researchers; providing training at regional and national level and assisting local state and federal agencies and museums. The collection management program oversees a large collection (some 30,000+

specimens under 15000 catalog entries), the bulk of which consists of natural history specimens. One of the fossil preparator positions is also involved in the museum collection program and is responsible for preparing reports, conducting annual inventories; co-ordinating loan paperwork with outside and contract researchers; preparing and maintaining accession files; and accessioning and cataloging specimens.

The majority of the 30,000+ specimens in the museum collection are natural history items. The on-going baseline and research studies in the various natural resources management and research programs in the park generate several thousand specimens a year which makes the collection and actively used and growing one. A vast majority of the projects identified in this Resource Management Plan will generate thousands of additional natural history specimens which will need to be accessioned, catalogued, and cared for.

The paleontological staff is adversely affected in meeting the requirements of the paleontological management program because of the burden of the collection management program, even when the latter is being done at a less than minimally acceptable level. This additional workload results in the park paleontologist being unable to complete needed research and other field activities while the one fossil preparator has a significantly reduced amount of time available for preparing fossil in the laboratory.

The collection at Dinosaur is large and has an estimated value of over 2.5 million dollars. However, record keeping and accountability and storage do not meet NPS standards, specimens are not cataloged, loans are not renewed or followed up on, data associated with specimens is not always obtained, etc. This situation will worsen as thousands of additional specimens are generated by the on-going research and baseline activities being conducted within Dinosaur. The proposed additional staffing for the biological resources management program (see: PROGRAM ADMINISTRATION: BIOLOGICAL RESOURCES) will further exacerbate this problem.

There is an immediate need for 2.0 additional FTEs for permanent staff and a minimum of 2.4 FTEs for seasonal staff. The permanent FTEs are identified in DINO-N-021.101 (Increase Paleo Resource Staff). Seasonal FTEs for continuing activities are identified in high-priority project statements such as DINO-N-500.008 (Gather Baseline Geological Data), DINO-N-551.001 (Protect Quarry Fossils), DINO-N-572.002 (Establish Paleontological Resources Monitoring Program), and DINO-N-573.001 (Excavate and Preserve Fossil Resources). A .4 seasonal FTE is identified that can be sequentially used in a series of limited duration projects, such as DINO-N-064.001 (Upgrade and Preserve Paleontology Library), DINO-N-551.003 (Document Quarry Excavation History), etc.

This increased staffing is related to a number of servicewide issues, particularly N20 and N23. The seasonal staff will be committed to high priority paleontological resources activities, such as monitoring the 300+ known paleontological sites in the monument, conducting mitigation and salvage excavations of threatened fossil localities, preparing and repairing the 1500+ in-situ bones in the Dinosaur Quarry inside the Quarry Visitor Center, gathering baseline geological data, and entering baseline data into databases and preparing such data for GIS. The permanent FTE will take over nearly all of the collection management activities currently conducted by the park paleontologist and fossil preparator and will manage the collection program at a level which meets NPS standards. This position will free the paleontological staff from most collection management duties (except supervision) and allow them to direct that time to pressing issues in the paleontological resources management program. The other permanent FTE will perform clerical duties associated with all management activities which are performed by the paleontology staff. The distribution of these FTEs is:

GS-1016-07	Museum Technician (Curatorial)	1.0 FTE
GS-1016-07	Museum Technician (Excavation)	0.8 FTE
GS-1016-05/07	Museum Technician (Monitoring)	0.4 FTE
GS-1016-07	Museum Technician (Lab Prep)	0.4 FTE
GS-1350-07	Geologist	0.4 FTE
GS-303-04	Clerk	1.0 FTE
GS-025-05	Park Ranger (Miscellaneous)	0.4 FTE

With the addition of the FTEs and funds for these positions, a number of continuing high-priority resource management programs could be undertaken at a level commensurate with program needs. Additional funding would be needed for special initiatives, research projects, and contract resource management studies and inventories.

3. RESOURCE PROTECTION AND INTERPRETATION

There are critical unfunded and unstaffed needs for protection and interpretation of natural resources which are independent of proposed monitoring, research, and mitigation needs. These are needed just because the resources and resources values exist and are vulnerable to degradation. Project statements DINO-N-041.001, DINO-N-041.002, DINO-N-042.001, DINO-N-042.002 and DINO-N-042.003 discuss these needs. We have chosen to identify the protection and interpretation needs in "staffing" project statements to highlight their importance. If the needed FTEs and funding were distributed among the many project statements, any given project statement or resource might show less than 0.1 FTE (an exception exists for

protection of wildlife species from illegal hunting). Furthermore, seasonal employees hired in protection and interpretation functions may effectively protect or interpret a variety of resources at the same time. For example, a hunting patrol might equally serve to protect elk, mule deer and bighorn sheep.

The collective need for staffing for resource protection and interpretation is $340,900 and 11.9 FTEs.

Protection activities for natural resource management would concentrate on identifying, reducing, mitigating and/or eliminating visitor impacts to endangered and sensitive species, rare plants, wildlife species subject to illegal hunting, river campgrounds, and the like. Those activities would further assist in identifying impacts associated with consumptive and/or extractive uses within the park and on adjacent lands. Interpretive activities would include both on-site and remote programs to educate visitors and other local users about natural resource issues and programs.

At present, interpretive staffing is so low as to severely limit regular personal interpretive activities about fossil resources, the fossil resource management program, or current research. Without such programs, visitors will remain ignorant of the diversity and importance of the resource for which the monument was originally established, will not be aware of programs currently underway to identify and protect those resources, and will not know of the exciting and significant discoveries being regularly made at Dinosaur. Increased seasonal interpretive staffing is needed in order to present a regular schedule of talks within the Quarry Visitor Center, to provide a regular schedule of campfire programs, to provide paleontology programs targeted at children, to provide information on appropriate and inappropriate behavior at paleontological sites, to meet requests for information about fossils, and to provide outreach programs to local schools about park fossil resources and the need to protect them. Funding is needed for both the increased staff and support costs (vehicle rentals, supplies and materials, etc.).

Current seasonal law enforcement staffing is such that even areas with significant fossils receive no regular patrols. There have been an increasing number of incidents of vandalism and theft at fossil sites over the last few years. Increased staffing and support costs are needed to provide for paleontological site patrols. Such patrols will increase documentation of sites, increase investigative reports for sites which are vandalized, and increase the apprehension of violators. The paleontologic staff will work with patrol rangers to familiarize them with the signs of fossil excavations and the areas to be patrolled.

Limited interpretive staffing also precludes any regular personal interpretive activities about geological resources, the geological resource management program, or current research. As with paleontological resources, visitors will remain ignorant of the diversity and importance of the geologic resource, of programs currently underway to identify and protect the resources, and of the geological discoveries being made at Dinosaur. Increased seasonal interpretive staffing is needed in order to conduct the same types of interpretive efforts described for paleontological resources above. These two subject areas are closely tied to each other and need a balanced presentation to foster understanding. Again, funding is needed for both the increased staff and support costs.

4. GEOGRAPHIC INFORMATION SYSTEM

Maintaining a UNIX based GIS system requires a full FTE. A UNIX operating system, while more powerful than DOS is also more complicated and requires more maintenance. A full time computer manager will be needed to:

1. Maintain hardware.
2. Maintain software.
3. Act as GIS manager. Duties include standardizing themes, aiding users, organizing data, and accessing data needs.
4. Help maintain Headquarters and quarry computers as needed.

The DOS based GIS system located in the Quarry VC will be maintained by present paleo. staff.

B. NATURAL RESOURCE MANAGEMENT ISSUES

1. THREATENED, ENDANGERED OR SENSITIVE SPECIES

The major issues related to endangered species in Dinosaur can generally be categorized with servicewide issues N02 and N03 (Impacts on Threatened, Endangered and Other Sensitive Animals and Plants).

Dinosaur contains a large number of endangered and threatened species: Colorado squawfish, razorback sucker, humpback chub, bonytail chub, peregrine falcon, bald eagle, and Ute ladies tresses orchid. The threatened Mexican spotted owl may occur in the park. Many other species are identified as candidates for federal listing, listed on State endangered species lists, or simply

regarded as sensitive. These include nearly 40 plant species, certain raptors (ferruginous hawks, goshawks), bats and river otters. For many of these species, Dinosaur constitutes the core of their range, provides critical habitats for certain life stages, or is integral to overall recovery efforts. Federal laws, agency policies and directives, and recovery plans prescribe certain activities to protect and manage these resources.

Other than program administration activities, most field efforts associated with these resources have been provided by special project funds. NRPP has partially supported peregrine falcon recovery efforts from 1989 through 1991; RMRO provided limited funding in 1992 and 1993. Cursory surveys were conducted for Mexican spotted owls utilizing employees and volunteers from the peregrine work. Assistance to endangered fish researchers has been provided on a limited basis incidental to other work. NRPP is funding some research on humpback chub and razorback sucker. WASO-WRD funded data collection (1991, 1994) for a riparian rehabilitation project. Integral to that project was locating, marking and characterizing Ute ladies tresses orchids. River otters were reintroduced in 1991 and 1992 by the Utah Division of Wildlife Resources with funding assistance from RMRO.

The project funds which supported many of efforts are no longer available. NRPP funding for peregrine falcon recovery terminated in 1991. WASO-WRD funding was provided for two separate years. No base funding is available to support these high priority activities on threatened, endangered and sensitive species.

Immediate high priority unfunded needs relative to endangered species include:

1. continuation of peregrine falcon recovery efforts (DINO-N-461.001),
2. monitor Ute ladies tresses orchid (DINO-N-340.002),
3. assisting other agency research and monitoring on endangered fish (DINO-N-465.002),
4. initiating surveys for Mexican spotted owls (DINO-N-463.001), and
5. assess and mitigate future habitat needs for wintering bald eagles (DINO-N-462.002).

For these 5 projects, the collective annual need for base funding within the park is for $68,000 and 2.2 FTE of seasonal services. An additional $40,000 annually is identified for research on endangered fish.

2. GRAZING ISSUES

The major issues related to grazing in Dinosaur can be categorized with servicewide issue N19 (Loss of Park Resources Due to Consumptive Practices).

Current grazing management actions include issuing permits for authorized grazing, coordinating activities and permits with BLM, incidental checks of stocking levels and dates of use on authorized allotment, incidental checks for grazing trespass, and efforts to reduce or eliminate trespass through negotiation with ranchers and the BLM.

About half of the authorized AUMs were eliminated at the end of the 1985 Grazing Year. Rather than reduce the need to manage grazing, the terminations increased our need because of trespass grazing. There are significant problems with trespass grazing in at least 7 widely scattered parts of the park, but staffing is not sufficient to monitor and correct such problems. Such trespass grazing modifies vegetation complexes, displaces wildlife native species, impacts upland water resources and their associated wetlands, disturbs cultural resources and degrades visitor experiences. Field monitoring of authorized grazing is insufficient. Range surveys need to be conducted on overgrazed allotments to facilitate reductions in grazing. Boundary fencing is the only realistic long-term solution for more effective management of authorized grazing and for elimination of trespass grazing. Additional funds and staffing for the following high priority unfunded activities:

1. monitor stocking and utilization of authorized allotments (DINO-N-632.001),
2. conduct range surveys to eliminate overgrazing and reduce attendant impacts on park resources (DINO-N-632.003),
3. study impacts of grazing on vegetation, soils, wildlife, recreation, cultural resources, etc. (DINO-N-632.002),
4. monitor trespass grazing, provide appropriate law enforcement response (DINO-N-632.001),
5. fence boundary to preclude continued trespass (632.004).

For items 1, 2, and 4, the collective annual need within the park is for $33,000 and 0.5 FTE of seasonal services. The recurring unfunded need for item 5, boundary fencing, is $110,000 and 1.0 FTE of seasonal services. An additional $50,000 annually is identified for research and monitoring of grazing impacts.

3. INVENTORY AND MONITORING

Each of the project statements (noted below) related to inventory and monitoring in Dinosaur can be categorized by servicewide issue N20 (Lack of Basic Data: Insufficient Understanding of park Ecosystems and Threats to Them). Each of the individual project statements also identify other servicewide issues: N02, N03, N05, N07, N13, N17, N19 and N20.

A number of baseline inventories have been completed (e.g. native and non-native fish, mammals, birds, visibility, aquatic invertebrates, general vegetation, rare plants, ambient sound, river hydrology) although some need to be expanded or updated. These have often been done on a shoestring - with volunteered services, with donated services from other agencies, and with the commitment of some staff funded by ONPS or related project monies. Others baseline inventories are in progress (e.g. herptiles, insects, lichens) and need additional funding support for completion. Where inventories have been completed, emphasis needs to shift to monitoring programs.

Baseline inventories need to be completed on soils, non-vascular plants, non-native plants, upland water resources, wetlands and a few other resources.

A number of basic resource monitoring programs are in place or ready to be implemented. These include programs for monitoring rare plants; ambient sound; human impacts in river campgrounds; distribution and habitat utilization of various fauna of special management concern (e.g. bighorn sheep, river otters, elk); range conditions on selected grazing allotments; etc.

Rare plant monitoring provide a cogent example of the overall need. A 3-year inventory of rare plants and the general flora of Dinosaur was completed in 1989. This work was supported by both CPSU and monument funds. At the conclusion of the inventory, RMRO and monument funds were committed to prepare a Rare Plant Monitoring Program. A monitoring plan is now completed which stratifies monitoring efforts based on plant rarity, vulnerability and susceptibility and also provides some new or modified field techniques. The program should serve as a prototype for rare plant monitoring across the Colorado Plateau. Funding was granted from RMRO in 1992 to begin the monitoring program. Nearly half of the initial effort was completed in the first year. Assistance in completing the initial phase was requested from other Colorado Plateau parks but no funds were obtained. Staff or funding necessary to even complete initialization this program has since not been available.

The highest priority inventory and monitoring projects include:

1. monitor rare plants (DINO-N-340.001),
2. inventory upland water resources (DINO-N-210.001),
3. complete inventory of insects (DINO-N-451.001),
4. complete inventory of lichens (DINO-N-321.001), and
5. inventory non-native plants (DINO-N-350.001).

For these 5 projects, the collective annual unfunded need within the park is for $43,000 and 0.5 FTE of seasonal services. An additional $50,000 and $21,000 are identified for research in years 1 and 2.

The single highest priority for inventory has been a soil survey (DINO-N-520.001). The cost to the NPS had been estimated at about $0.50 per acre (i.e. over $100,000). The Soil Conservation would contribute the remaining costs. Funding ($100,000) for a soil survey was obtained in FY 1993 and the SCS began field work immediately. Final reports and maps are expected in 1995.

Other important unfunded inventory and (annually recurring) monitoring needs include:

1. monitoring cottonwood and boxelder regeneration in riparian areas (DINO-N-311.002),
2. inventorying and monitoring wetlands (DINO-N-330.002),
3. monitoring population levels and distribution of bighorn sheep, elk and mule deer (DINO-N-411.101, 201, 301),
4. monitoring ambient sound (DINO-N-612.001),
5. monitoring upland water resources (DINO-N-210.002),
6. monitoring fire effects (DINO-N-396.001-.002), and
7. monitoring erosion in Echo Park (251.003).

The aggregate annual cost of items 1, 2, 3, 4, 5 and 7 is $55,500 and 1.7 FTEs of seasonal services. About $44,000 is needed over 2 years to complete the inventory and initial characterization of wetlands. Monitoring of fire effects has been partially funded by FIREPRO; the annual need is $28,400 and 1.0 FTE.

Dinosaur does not have sufficient staffing or funding to implement the identified baseline inventory and resource monitoring programs. Without additional staff and funding, these programs will have to be suspended or foregone. Completed work will not become useless, but its value will be diminished considerably by the "gaps" that are about to occur.

4. EXTERNAL ISSUES

There are a multitude external threats or issues which need to be monitored or mitigated. These include monitoring threats to the Green and Yampa Rivers (DINO-N-212.001), monitoring air quality and visibility (DINO-N-110.002, DINO-N-120.001), maintaining continued access to portions of the park boundary (DINO-N-655.001), securing instream flow water rights on the Yampa River (DINO-N-240.001), monitoring selected consumptive and extractive activities on adjacent lands (DINO-N-710.001), selecting an access route along the Echo Park road (DINO-N-653.001), and assessing potential boundary changes (DINO-N-654.001). Considerable interagency coordination will be necessary to effectively deal with these issues.

These issues fall into a variety of servicewide issues including N02, N10, N11, N12, N13, N16 and N24. Current activities (described in DINO-N-010.001) include some efforts to monitor and mitigate external threats but insufficient funds and staffing limit the level of effort.

The most critical unfunded needs for dealing with these issues are included in DINO-N-021.101. The additional permanent staffing identified in DINO-N-021.101 will be sufficient to accomplish the monitoring and coordination activities described in the project statements listed in this section.

5. NATURAL RESOURCE MITIGATION

This section is intended to identify those high priority, hands-on activities designed to mitigate the impacts of human manipulations and consumptive uses which have occurred in the past. The project statements relate to a variety of servicewide issues but are concentrated in N04, N05, and N06.

Current management actions include limited planning supported by ONPS funds (e.g. DINO-N-010.001) and initial or prerequisite monitoring supported by special project funds (e.g. data collection for Hog Canyon riparian rehabilitation funded by WASO-WRD). Current park ONPS funds and staff are insufficient to accomplish any of the tasks noted below.

Those proposed projects of highest priority include:

1. rehabilitate Hog Canyon riparian area (DINO-N-330.003),
2. control tamarisk in selected locations (DINO-N-350.002)
3. control Russian knapweed, Cub Creek (DINO-N-350.003)
4. rehabilitate disturbed lands (DINO-N-361.001),

5. establish additional populations of bighorn sheep (DINO-N-411.105),
6. relocate Echo Park Campground (DINO-N-643.001), and
7. construct a Science Center (DINO-N-643.002).

The proposed cost and funding for each of these projects varies by year. In aggregate, the required annual expenditures for items 1-6 range from $253,000 and 1.9 FTEs to $201,000 and 1.8 FTEs. The projected cost of item 7 is a total of $600,000. It is included because of its presence should generate donated or lower cost research of sufficient volume to pay for itself.

6. OTHER IMMEDIATE NATURAL RESOURCE ISSUES

There are a few other natural resource issues which are of immediate importance but which do not fit easily within the categories above. These include management of elk, boundary issues, river management planning and certain basic research needs.

Elk populations have expanded very rapidly in the past 10 years, to the point that Dinosaur may be on the verge of having an "elk problem" (servicewide issue N01). Forage utilization in some areas is considerably higher than would have been authorized for domestic livestock. There are indications of heavy use and possibly significant impacts on some upland water resources and associated wetlands. Interagency research is proposed (DINO-N-411.202) to determine distribution, movements, demography and impacts of elk on Blue Mountain. Both the Bureau of Land Management and Colorado Division of Wildlife have indicated an interest in participating in such research.

The configuration of Dinosaur's boundary is such that it precludes ecologically-sound management of several resources and predisposes park resources to impacts from external sources (servicewide issues N02, N03, N06, N10, N11, N16, N17, N19 and N23). Local watersheds, viewsheds, animal populations, primary landforms, etc. all extend outside the monument. There have been many suggestions offered in recent years regarding possible boundary changes. These range from minor changes to incorporate portions of access roads to the park or straighten dog-legged boundary section to rather substantial expansion of park boundaries to include intact local watersheds and landforms (see DINO-N-654.001). Consideration of boundary changes should be conducted through a more formal process. Assistance from RMRO and DSC may be required to conduct the assessment. Given the potential impact to park resources, some adjustments may be critical to the long-term viability of park resources.

Dinosaur's River Management Plan was implemented in 1979. Since that time, research and monitoring has increased the information relative to existing and potential impacts of recreational river use (servicewide issue N18), several new visitor use issues have been raised, and new policies regarding equipment and sanitation need to be incorporated. Minor adjustments in administration of the plan are made as information and policy changes warrant. Major revisions of the plan may be deferred until additional funding and staffing is available (see DINO-N-625.001).

Instream flow water rights are a critical issue for the Yampa River (servicewide issue N13). Since the NPS claims failed in adjudication, the Recovery Implementation Program has proposed purchase of instream water rights to protect endangered fish. It would seem prudent to assess water needs for other resources above and beyond that needed for endangered fish. If flows for endangered fish are sufficient to maintain other resources and resource values, no further action would be needed other than to support acquisition of those flows. If additional instream flow (volume, timing, etc.) were needed to protect other resources and values, acquisition of such could be coordinated with the endangered fish effort (see DINO-N-240.001).

Other high priority research needs were not discussed in earlier sections. These include AQRV studies (DINO-N-110.001), investigations of presettlement vegetation patterns (DINO-N-330.001), research on the effects of reoperation of Flaming Gorge Dam (e.g. DINO-N-350.004; DINO-N-450.001), and bighorn sheep studies (initially funded by NRPP; DINO-N-411.101). With these and other research needs, we believe that an addition of $50,000 for research to Dinosaur's base fund allocation would be appropriate to ensure completion of the research over a period of years.

C. PALEONTOLOGICAL ISSUES

Dinosaur National Monument was established in 1915 to preserve Mesozoic age vertebrate fossils being quarried by the Carnegie Museum of Natural History. The Carnegie quarrying operations were focused primarily at a single large quarry seven miles north of Jensen, Utah. This quarry is situated in the Brushy Basin Member of the Morrison Formation (Upper Jurassic: Tithonian/Kimmeridgian). However, they did collect several significant dinosaur specimens from areas outside of, but close to, their main quarry. The expansion of the monument in 1938 added significant acreage of Mesozoic age rocks, very large amounts of Paleozoic age rocks, and moderate amounts of post-Mesozoic rocks and unconsolidated sediments (see Figure 1). Even a cursory examination of the

scientific literature shows that all these rocks have the potential for producing abundant and significant fossil material.

1. DOCUMENTATION

The types of needed baseline documentation for the monument's fossil resources is quite variable, ranging from historical excavation records to data on distribution and significance. The monument has a very incomplete baseline data set for its paleontological resources. Although the nature of the baseline data varies (see discussions below), all baseline data is needed to 1) evaluate the distribution, abundance, and significance of the paleontological resources within the park, 2) to develop a more comprehensive paleontological management program, 3) identify additional needed studies, 4) identify localities and specimens which are threatened by erosion, theft, or vandalism, and mitigate such threats, 5) enhance the park's program for excavating, collecting, and studying specimens, 6) develop a monitoring program for fossil sites, 7) increase the number of outside paleontological researchers working in the park and to use their scientific activities to enhance the park's management and science program, 8) prevent negative impacts on the paleontological resources by other park management actions and visitor activities, 9) to enhance the monument's interpretive programs and activities, and 10) plan and taget protection patrols.

a. PRECAMBRIAN AND PALEOZOIC PALEONTOLOGICAL RESOURCES

Baseline data on the monument's paleontological resources beyond the confines of the Quarry Visitor Center is extremely limited. Precambrian and Paleozoic fossils have not been systematically examined, although they have been studied (usually in a limited extent) in some geological studies (Untermann & Untermann 1954, Dreise 1982, Schlipp, in progress 1990). This information is spotty and does not constitute valid baseline data.

The Precambrian and Paleozoic formations within the park are predominately marine and are widespread on the Colorado Plateau. Marine invertebrates can be spectacularly abundant at some horizons, even to the point of being the predominant rock forming material. This, combined with the extensive amount of Precambrian and Paleozoic rocks exposed within the park, makes a simple inventory of paleo localities of these sediments impossible. Such an inventory would likely generate tens of thousands of localities, would be prohibitively expensive, and would not be likely to produce baseline data which would be useful to either management or science.

In light of the above discussion, the following steps should be taken in order to improve our knowledge of these resources in a way

that will allow them to be managed and protected in a useful manner.

1. From the present onward, establish locality files for all sites from which Precambrian and Paleozoic fossils are collected and deposited in a museum collections (either in-park or an outside repository). In most cases, such collections will be made in the course of a scientific study and the specimens either mentioned or figured in the resulting publications. These specimens and their localities will become part of the data which future researchers will return to. Locality files will enable us to direct future workers to the sites as well as to allow us to evaluate other park actions for possible negative impacts on the sites.

   Each Locality File will contain a completed locality form, maps, photographs, copies of field notes, catalogued specimen lists, list of publications describing the site and/or specimens collected from the site, cross references to other database files, quarry maps, correspondence, and other types of relevant data. Each file will serve as the primary information source for that site.

2. Obtain information on past studies which have resulted in the collection of Precambrian and Paleozoic fossils which have been deposited in collections (either in-park or outside repository). The rationale for such files is as in 1 above. This will require contacting any living researchers or obtaining copies of locality records from other institutions. Because of the limited number of Precambrian and Paleozoic studies which have been conducted within the monument it is likely that the number of individuals and researchers involved will be small.

3. Monument staff should meet with specialists knowledgeable about the formations within the monument. Such a meeting might take the format of a one or two day group meeting during which researchers can articulate the real or potential significance of Precambrian and Paleozoic paleontological resources within the monument and help the staff to outline issues which need to be addressed in the monument's Resource Management Plan. Following this meeting the Resources Management Plan would be revised to reflect these recommendations and project statements would be written to implement these recommendations.

b. TERRESTRIAL MESOZOIC PALEONTOLOGICAL RESOURCES

There are thirteen Mesozoic age rock formations within the monument. These formations contrast with the Precambrian and Paleozoic formations in the following ways:

1. The Mesozoic formations in the monument are primarily terrestrial (9 out of 13) rather than marine in origin.

2. Because terrestrial environments are less uniform than marine environments, their sedimentological record is more complex, and more difficult to decipher.

3. Terrestrial sedimentary environments are more subject to erosion than marine sedimentary environments, so the terrestrial sedimentological record is less complete.

4. Terrestrial organisms are, on average, less abundant. less diverse, and less widespread than marine organisms.

5. As a result of 2, 3, & 4 above, fossils of terrestrial organisms are much rarer and less well preserved than those of marine organisms.

The terrestrial Mesozoic formations within the monument are:

1. Frontier (in part) [Youngest]
2. Dakota
3. Cedar Mountain
4. Morrison
5. Entrada (in part)
6. Carmel (in part)
7. Navajo
8. Chinle
9. Moenkopi [Oldest]

For each of these formations the following documentation is needed:

1. Inventories of paleontological sites, including all macro- and micro-invertebrates, macro- and micro-plants, invertebrates, and vertebrate and invertebrate trace fossils which are of significance.

2. Sedimentological and stratigraphical studies which will identify the mosaic of environments within each formation, how these environments changed through time, identify marker beds for correlation, identify index

fossils, use fossils to establish internal chronologies, and conduct (when possible) an isotopic dating program to provide absolute ages for formation boundaries, major geological events and subdivisions of the formation. These studies will provide the geological and paleo-environmental framework for evaluating the results of the paleontological surveys. Thus, sedimentological and stratigraphical studies should be done concurrently or precede paleontological inventories in the same formation.

In 1990 three multi-year projects began which provide some of the baseline data outlined above. The first is a paleontological inventory of the Morrison Formation. During the first two seasons over 280 localities were identified and had site forms completed on them. A total of over 300 sites are now known and at least partially documented. The second study focuses on the sedimentology and stratigraphy of the Morrison Formation. The results of these first two studies should serve as a model for the baseline data needed for terrestrial Mesozoic formations. The third study is inventorying the vertebrate trackway localities within the monument, a study covering several formations. All three studies will be completed in 1993.

c. THE DINOSAUR QUARRY:

A comprehensive data base is needed for the excavation and development of the Dinosaur Quarry within the Visitor Center near Jensen, Utah. Amongst the needed data is:

1. List of specimens collected, current repository, institutional catalog number, preparation state, genus and species identification, bone type, taphonomic data, photographs, historical photographs, standard measurements, etc.

2. Copies of all historical photographs, diaries, journals, correspondence, scientific and popular articles, etc.

3. Re-drafting of all quarry maps from all institutions to a common scale to form a single master map of all excavated material.

4. Digitizing of master map and entry into Paleo GIS.

5. Entry of data from 1 and 2 above into associated databases in GIS. Tie bones to databases through specimen catalog numbers.

6. Accession and catalog data gathered in 1, 2 & 3 above and curate to NPS standards.

d. MARINE MESOZOIC PALEONTOLOGICAL RESOURCES:

There are several Mesozoic formations within the park which are marine, either wholly or in part. These are:

1. Mancos Shale [Youngest]
2. Frontier (in-part)
3. Mowry Shale
4. Stump
5. Entrada (in-part)
6. Carmel (in-part) [Oldest]

These formations (or parts of formations in cases such as the Carmel) present problems similar to those of Paleozoic formations because of the abundance of marine invertebrates. In general, formations 1-6 above need baseline data along the lines identified for Paleozoic formations;

1. From the present onward, establish locality files for all sites in formations 1-6 from which fossils are collected and deposited in museum collections (either in-park or an outside repository). In most cases, such collections will be made in the course of a scientific study and the specimens either mentioned or figured in the resulting publications. These specimens and their localities will become part of the data which future researchers will return to. Locality files will enable us to direct future workers to the sites as well as to allow for evaluation of other park actions for possible negative impacts on the sites.

   Each Locality File will contain a completed locality form, maps, photographs, copies of field notes, catalogued specimen lists, list of publications describing the site and/or specimens collected from the site, cross references to other database files, quarry maps, correspondence, and other types of relevant data. Each file will serve as the primary information source for that site.

2. Obtain information on past studies which have resulted in the collection of fossils from formations 1-6 which have been deposited in collections (either in-park or outside repository). The rationale for such files is as in 1 above. This will require contacting any living research-

ers or obtaining copies of locality records from other institutions. Because of the limited number of relevant studies which have been conducted within the monument on these formations it is likely that the number of individuals and researchers involved will be small.

3. Monument staff should meet with specialists knowledgeable about the formations within the monument. Such a meeting might take the format of a one or two day group meeting during which researchers can articulate the real or potential significance of paleontological resources of formations 1-6 within the monument and help the staff to outline issues which need to be addressed in the monument's Resource Management Plan. Following this meeting the Resources Management Plan would be revised to reflect these recommendations and project statements would be written to implement these recommendations.

e. CENOZOIC (INCLUDING QUATERNARY) PALEONTOLOGICAL RESOURCES

Only two formally named Cenozoic formations, the Bishop Conglomerate and the Brown's Park Formation, occur within the monument, although unconsolidated Quaternary superficial deposits are common. All these sediments are terrestrial in origin and have documentation needs similar to those identified for Mesozoic terrestrial paleontological resources, i.e.;

1. Inventories of paleontological sites, including all macro- and micro-invertebrates, macro- and micro-plants, invertebrates, and vertebrate and invertebrate trace fossils which are of significance.

2. Sedimentological and stratigraphical studies which will identify the mosaic of environments within each formation, how these environments changed through time, identify marker beds for correlation, identify index fossils, use fossils to establish internal chronologies, and conduct (when possible) a radiocarbon dating program to provide absolute ages for formation boundaries, major geological events and subdivisions of the formation. These studies will provide the geological and paleoenvironmental framework for evaluating the results of the paleontological surveys. Thus, sedimentological and stratigraphical studies should be done concurrently, or precede, paleontological inventories in the same formation.

Although only a few mappable caves are known within the monument, the extensive limestone within the monument makes it likely that

caves are more common than currently thought. All caves have the potential to contain Quaternary fossils. As caves are identified in the monument they will need to be evaluated for their paleontological content, including those high up on canyon walls, as these have produced important fossil bird specimens in other NPS units in the southwest.

Because of the relatively recent age of Quaternary sediments, there is a strong likelihood that some fossil localities may have associated archeological materials. When such an association occurs those sites would be subject to the more stringent guidelines of NPS-28 and ARPA. Because Quaternary fossil material may be important for understanding the origin and evolution of the modern biota and because of the possibility for archeological materials in such sites, the cultural, biological, and paleontological programs within the park will need to co-ordinate activities whenever Quaternary paleontological activities are undertaken.

f. AERIAL PHOTOGRAPHY

Present stereo air photography of the monument is at too coarse a scale (1:12,000) to provide the needed resolution for the accurate plotting of fossil localities. A scale of 1:3000 is needed by the paleontological program. This will require new flights, development of negatives, and printing of multiple copies for archives, locality files, and field and office use. The need for these new photos is immediate, because paleontological inventories are already underway in the monument and photos are needed for accurate plotting of sites in the field. Failure to provide photos at the needed scale in a prompt manner will require park staff to duplicate efforts by having to relocate all sites at some time in the future to provide accurate field mapping.

It is likely that in addition to standard color aerial photos more exotic types of imagery such as Lansat, Infrared, etc. will also be needed for paleontological field activities.

g. COMPUTER SEARCHES

Computer literature searches (through services such as GEOREF) are needed for a variety of paleontological subjects. Such searches can provide references needed for documentation of park paleo resources and for the park paleontology science program.

2. EXCAVATION AND RESEARCH

The paleontological excavation and research program at Dinosaur involves park staff, contractors, and outside researchers.

Excavation may be undertaken as a salvage project in order to mitigate threats to a significant specimen or as part of a scientific project. Research activities may provide baseline information for management, may be part of a resource management action, or be undertaken to answer a scientific question. Results of the excavation and research program is made available to the visiting public through personal and non-personal interpretive services.

a. NON-QUARRY EXCAVATIONS

Non-quarry excavations are undertaken to mitigate destruction, as a resource management action, and/or as part of a scientific research project. Excavated specimens range from near microscopic vertebrates and invertebrates to adult dinosaurs. Excavations are generally conducted by two museum technicians with the assistance of a small number of trained and experienced volunteers. Outside researchers occasionally excavate as part of a project, although this has been a rare event.

Existing staffing is inadequate to accomplish all excavation work needed. As the number of documented fossil sites continues to grow (300+ at present) the backlog of sites needing work will grow. There is no seasonal paleontological staff. Seasonal paleontological staffing is needed in order to address immediate needs. Such staffing would allow for permanent staff to divide into multiple excavation teams to handle more than one site at a time. Because of the technical nature of the excavation work, the great scientific value of the specimens being excavated, and the ease with fossil remains are damaged during excavation, it is very difficult and quite time consuming to train unskilled individuals, especially within the confines of existing staff. Seasonal paleontological staff must be individuals with requisite background and experience and will therefore likely be recruited from colleges and universities.

Funding is needed to contract excavations with outside institutions. Such excavations may be done under direct supervision of park staff and professionals from the outside institution. The excavation crews working under contract would be composed of experienced individuals and would require no training from park staff. Because of the number of localities needing attention, contract crews would work in addition to seasonal paleontological staff, not in lieu of that staff.

b. QUARRY EXCAVATIONS

Up until the mid 1980's, Quarry excavations were the main focus of the paleontological excavation program. More recently, however, the fossil management program has begun to direct its attention to the fossil resources beyond the confines of the quarry building. Work on those resources could only be accomplished at the expense of reducing the time spent on the excavation program at the Quarry. Thus, time spent in quarry excavations has been reduced by approximately 90%. Although the quarry is about 80% excavated, it is possible that some significant specimens remain to be discovered.

With the excavations 80% complete, only a small amount of the sandstone overburden remains on the quarry face. Recent studies (Turner and Peterson, pers. comm. 1991) indicate that the geological data present in the overburden is significant and should be preserved. In addition, the morphology of the river channel makes it unlikely that many specimens are present under the remaining overburden (Turner and Peterson, pers. comm. 1991). Thus future excavations in the quarry should be limited to only those which are absolutely essential and from a management standpoint the quarry excavation should be considered as essentially completed. Additional preparation work is needed, however, on many bones already exposed on the quarry face. This would consist of complete exposure of ends of limb bones, etc. which is needed for accurate measurement and identification. Such relatively easy preparation work can be done with seasonal staff, allowing full time paleontological staff to tackle more complex and difficult projects.

c. RESEARCH

Scientific research is a crucial component of the monument's paleontological resources management program and is encouraged and supported. Research is conducted by park staff, contractors, and academic researchers and may be directed at solving a resource management issue or for purely scientific purposes. The results of such work is made available to the scientific community through publication in scientific journals and presentations at scientific meetings. Research results are made known to the general public through personal and non-personal interpretive services (quarry talks, self guided trails, publications, park newspaper, and exhibits).

Research needs are generated in a number of ways. For example, while research and resource management projects refine our knowledge about the monument's fossils they also raise additional deeper questions about the resource. On the other hand, paleontological and geological discoveries elsewhere may raise previously

unthought of questions about the park's fossils. Finally, some questions are the result of interpretive needs for fostering public appreciation for paleontological resources. New research has a direct impact on our understanding of park resources, their significance, how they are managed, and what the interpretive program tells the public about them. Paleontology and geology are active, growing disciplines and such growth will continue to have implications for park resources.

The present park staff is not of sufficient size to conduct all needed research. Staff size is too limited, other demands intrude on research time, park facilities are not equipped for all types of needed research, and most importantly the diversity of types of studies needed is such that many discipline experts are needed. Outside researchers (both academic and contract) have conducted some needed research with excellent results, but, as can be seen from the list above, much research remains to be undertaken. As baseline data grows on the monument's fossil resources, the need for subsequent research increases. Funding is needed to establish and sustain a continued research program. Such monies will be used to contract with discipline experts to complete needed work. Estimated yearly funding needed for contract paleontological research is $25,000/year. This is based on NRPP funded research projects 1990-1992 and should support 2-3 projects per year.

The following is a brief and incomplete list of potential paleontological research projects which is needed at present. This list is not exhaustive and focuses primarily on Mesozoic terrestrial fossil resources. Additional, projects would be derived from geological and paleontological needs assessments called for elsewhere in this document.

1. Geochemistry and deposition of freshwater lakes in the Morrison Formation of Dinosaur National Monument: implications for Upper Jurassic paleoenvironments.

2. Taxonomy and paleoecology of freshwater gastropods in the Morrison Formation of Dinosaur National Monument.

3. Taxonomy and paleoecology of freshwater bivalves in the Morrison Formation of Dinosaur National Monument.

4. Taxonomy and paleoecology of plant macrofossils in the Morrison formation of Dinosaur National Monument.

5. Paleoecological implications of fossil pollen and spores from the Morrison Formation of Dinosaur National Monument.

6. Fossil Pollen and spores as indicators of the Morrison / Cedar Mountain boundary in Dinosaur National Monument.

7. Bibliography and Index of the Morrison and Cedar Mountain Formations and their equivalents.

8. Carbonate petrology of the Morrison and Cedar Mountain formations in Dinosaur National: implications for paleoenvironmental change across the Jurassic / Cretaceous boundary.

9. Systematics of ornithopod dinosaurs from Dinosaur National Monument.

10. Systematics of sauropod dinosaurs from Dinosaur National Monument.

11. Systematics of the genus Stegosaurus from Dinosaur National Monument.

12. Composition of the theropod fauna of Dinosaur National Monument.

13. Functional morphology of sauropod dinosaurs: implications for feeding and habitat segregation.

14. Systematics of the non-dinosaurian herpetofauna from the Morrison Formation of Dinosaur National Monument.

15. Rates of destruction of variously preserved fossils: implications for the management of fossil resources.

16. Ontogeny and allometric growth in Morrison sauropods: implications for paleophysiology and systematics.

3. MONITORING

a. NON-QUARRY PALEONTOLOGICAL RESOURCES

Some 300+ fossil localities are now known within Dinosaur and at least several times that number are likely to be found before all inventory work is completed. A monitoring program is needed in order to evaluate continuing threats to sites (such as erosion), to document changes in conditions through time, and to help develop priorities for the excavation and protection program. In addition, monitoring will include studies on erosional rates within different rock types within Dinosaur. This data along with baseline information will be used to help develop a program for cyclic prospecting of areas at differing time intervals (yearly, three

year, five year, etc.). Present staffing is insufficient to implement a monitoring program. Seasonal staffing is needed to conduct initial condition studies and to periodically re-examine sites and document changes. The staffing needed for the monitoring program is in addition to that needed for the quarry and non-quarry excavation programs.

b. CRACK MONITORING AT DINOSAUR QUARRY

Over the last fifty years excavations at the Dinosaur Quarry have removed a thick overburden of rock. The resulting isostatic rebound has lead to the development of a crack system and rejuvenated growth of natural, pre-existing cracks. The growth of these cracks increases the damage to fossils on the cliff. No baseline data is available on the growth and development of the crack system. A crack monitoring system needs to be designed and installed which will provide such needed information. This data, coupled with analysis of a limited historical photographic record will allow for the development of a long term management strategy to mitigate threats to the quarry resource posed by a growing crack system.

4. FACILITIES AND SUPPORT

a. PALEONTOLOGY LIBRARY

The paleontological library is an outstanding scientific library which receives considerable use by park staff and outside researchers. Present funding is not sufficient for library needs. The 10,000+ holdings need to be computerized, a program for rebinding damaged books need to be established, support for regular trips to nearby university libraries to photocopy older literature and to keep abreast of current literature, and to provide supplies and equipment for library curatorial needs. Computerizing holdings will require purchase of the appropriate program and a seasonal position for one year.

b. PALEONTOLOGY PREPARATION AND CONSERVATION LABORATORY

The paleontological laboratory is the site where preparation and conservation of fossil specimens takes place. Museum collections need to be removed from this area to allow for full utilization of the lab for preparation activities. A paramount concern is employee health and safety as dust and fume evacuation systems, and radon monitoring and control systems are needed immediately. Some present equipment (such as the fume hood) need to be relocated and retro fitted for the use of a bunsen burner. Additional equipment is needed to improve efficiency of preparation activities(digital scales, stirring hot plates, etc). A large compressor is needed to

allow for the use of more than one air-powered tool at a time. A system is needed to ease the moving of heavy specimens around the lab. Increased funding is needed for supplies and equipment annually consumed in preparation activities.

c. SUPPORT FOR PROFESSIONAL ACTIVITIES

Increased support is needed for paleontology staff's professional activities. This includes funding for visits to museum collections with relevant paleontological holdings, visits to other paleontological sites, attendance of staff at professional meetings, professional training, etc.

d. EQUIPMENT

Increased funding is needed to purchase equipment for research and resource management activities and documenting those activities. Included in these needs are cameras, lenses, binoculars, brunton compasses, video camera, etc.

Accurate plotting of localities in the field is often difficult due to terrain and inaccurate or dated topographic and geological maps. This is a particular problem where small stratigraphic differences of a few centimeters could represent hundreds of thousands or even million of years of Earth history. A portable satellite telemetry unit with appropriate resolution is needed in order to accurately locate site sites and to have highly accurate locality data for the paleontological GIS.

e) RESEARCHER/VIP HOUSING

Outside researchers and volunteers make significant contributions to the paleontological resources management program. The ability of the monument to attract and utilize volunteers is limited by the lack of suitable housing for these individuals. Some type of housing is needed which will provide living quarters, space for computers, equipment storages, showers, etc. A regional prohibition against new trailer pads or trailers rules these structures out as a solution which leaves apartments and dormitories as the primary options.

5. INTERPRETATION

See Section A.3. of the Overview for a description of personal services needs associated with the interpretation of paleontological resources.

a. NON-PERSONAL INTERPRETIVE SERVICES

Non-personal interpretive services about paleontological resources should be initiated. Interpretive wayside signs for select paleontological localities can reduce vandalism, theft, and ignorance. One or more trails with paleontological and earth history themes should be developed and signed. None presently exist in the monument -- a park that has some of the most significant paleontological and geological resources in the Service. Slide sets showing paleontological activities need to be developed for teachers and visitors. Paleontological protection messages should be placed in appropriate park handouts and publications. Temporary exhibitry is needed to allow for the development of exhibits about current discoveries. This will allow the visitor to know about current work as it goes on, not several years down the line when permanent exhibits are overhauled. This sense of immediacy is a powerful and exciting tool for building interest and appreciation in the resource. A trinocular head stereoscope with an attached video camera and monitor in the laboratory will allow the visitor to view the preparation of very small fossils under the microscope as it is being done. This would be a connection between the visitor and the preparator and foster protection of paleontological resources.

b. PLANNING

There is a need for improved interpretive planning relative to paleontological resources. Paleontology is a technical field which presents a challenge to staff to interpret new discoveries through both personal and non-personal services. Interpretative innovations are needed. Staff should investigate how paleontological resources are interpreted in other parks and should utilize outside specialists in interpretive training and planning. Funding is needed for travel to other NPS units interpreting paleontoloigcal resources and for attendance at appropriate professional meetings which may address educational and interpretive aspects of earth history.

6. PROTECTION

Current seasonal law enforcement staffing is such that even areas with significant fossils receive no regular patrols. There have been an increasing number of incidents of vandalism and theft at fossil sites over the last few years. Increased staffing and support costs are needed to provide for paleontological site patrols. Such patrols will increase documentation of sites, increase investigative reports for sites which are vandalized, and increase in the apprehension of violators. The paleontological

staff will work with patrolling rangers to familiarize them with the signs of fossil excavations and the areas to be patrolled.

7. LANDS

Significant fossil resources occur on non-NPS lands within and immediately adjacent to Dinosaur. The monument needs to develop co-operative agreements with other land management agencies (BLM, BUREC, etc.) for co-ordinated management of fossiliferous exposures contiguous with those in the monument. Such actions may include excavation and preparation of specimens, storage of collections, inventory and evaluation, etc.

The State Land Board has announced plans to sell paleontological artifacts from state school sections. Such sections exist in a number of areas of the park, most notably for fossils in the Rainbow Park Area. Paleontological resources in these areas include dinosaurs and associated vertebrate, invertebrate, and plant fossils. These exposures are contiguous with fossiliferous exposures on monument lands and the sale of state fossils would reduce the scientific information gained from monument lands.

Each state section in the monument needs to be surveyed and all paleontological localities documented and evaluated. The monument must monitor the State Land Board's sales plans for such sections and negotiate with them for the purchase of state sections with significant fossil resources.

E. GEOLOGICAL RESOURCES

Dinosaur National Monument has the most complete geological record of any National Park Service Unit (Hansen, pers. comm. 1988) and a wide array of structural and geomorphological features. The geological record is most complete in the Paleozoic and Mesozoic eras, with only a few PreCambrian and Cenozoic formations being present (Fig. GEOL-1). Dinosaur National Monument offers outstanding educational opportunities in geology for the general public

1. DOCUMENTATION

a. DOCUMENTATION OF PREVIOUS RESEARCH

The monument has a long history of study by geologists but does not have adequate documentation of these activities. The monument needs to identify geologists who have worked here and, where possible, obtain copies of diaries, field notes, photographs, and other types of documentation. Copies of all geological publications based totally or in part in the monument need to be obtained

for the Paleontology Library. Computer literature searches can be used to develop a list of such publications.

b. STEREO AIR PHOTOGRAPHY

Present stereo air photography of the monument is at too coarse a scale (1:12,000) to provide the needed resolution for all formations in order to accurate plot the location of measured sections, trace marker horizons, etc.). A scale of 1:3,000 will be needed for some formations. Many of these will be the same formations as identified under AERIAL PHOTOGRAPHY under PALEONTOLOGICAL RESOURCES. However, some unknown amount of additional 1:3,000 photography will be needed. That need will be determined through a geological needs assessment.

c. OTHER IMAGERY

Several types of specialized imagery (LandSat, infrared, etc.) is often useful for geological studies. There is some need for such imagery in Dinosaur, although its exact nature and extend remain to be determined.

2. RESEARCH

a. GEOLOGICAL NEEDS ASSESSMENT

The diversity of geological resources within the monument is such that it is not possible for staff to have all requisite knowledge to address all resource management and research needs. Staff can identify major geological needs related to Mesozoic terrestrial resources, but outside assistance is needed for other resources. Monument staff should meet with specialists knowledgeable about the geology of the monument. Such a meeting would take the format of a one or two day group meeting during which researchers would identify sources of documentation, the real or potential significance of geological resources, research needs, and help the staff to outline issues which need to be addressed in the monument's Resource Management Plan. Following this meeting the Resources Management Plan would be revised to reflect these recommendations and project statements would be written to implement these recommendations.

b. GEOLOGICAL MAPPING

Recent NPS contracted investigations by USGS personnel have elucidated a number of geological needs related to the Morrison Formation within the monument. Prime among these is a remapping of the Morrison at a scale appropriate for recording the thickness and distribution off all subdivisions (recent work has doubled the

number of formally recognized bubdivisions of the Morrison within DINO).

c. THE CHINLE/POPO AGIE PROBLEM

The identification of one formation within the Monument is of some dispute. Mapped variously as the Chinle Formation and the Popo Agie Formation, this late Triassic rock unit needs to be restudied geologically in order to be accurately identified and correlated. The identification has implication for the significance of fossils resources found within it.

d. SEDIMENTOLOGICAL AND STRATIGRAPHIC STUDIES

The Chinle/Popo Agie formation and the Cedar Mountain formation need to be studied in terms of the details of their environment, depositional environments, flora, fauna, how these changed through time, and how these formations compare with similar exposures in the region.

Other formations (including unconsolidated Quaternary sediments) within Dinosaur have a similar need for sedimentological and stratigraphical study.

e. PETROLOGICAL STUDIES

Petrographic studies are needed in at least the Morrison Formation and the Cedar Mountain Formations in order to understand the changes in environmental and geological history of these rock units and to help pin down the hard to identify boundary between these two formations.

f. CAVES

Several caves are known to exist within Dinosaur. These need to be evaluated for their geological resources. The park needs to be surveyed for other caves.

3. MONITORING

The development of a monitoring program will follow the identification of resources in the Geological Resources Needs Assessment (see: 2. RESEARCH above).

4. FACILITIES AND SUPPORT

a. GEOLOGY LIBRARY

Periodic computer geology searches (such as GEOREF) are needed in order to develop a comprehensive list of scientific publications relevant to the geology of the park. The park should proceed to obtain copies of all relevant publications for the paleontology library.

Funding is needed in support of travel to regional science libraries to photocopy needed geological literature for the paleontology library.

There is a need for some limited binding and book repair of geological publications.

b. EQUIPMENT

Geological activities carried out by the park, and to some extent outside researchers, are hampered by the lack of some geological equipment. Among the needed items are brunton compasses, Jacob's staff, rock saws, satellite telemetry unit, cameras, video cameras, binoculars, etc.

c. PROFESSIONAL SUPPORT

Increased support is needed for staff's professional activities in geology. This includes funding for visits to other geological research areas relevant to activities at Dinosaur, attendance at professional meetings, professional training classes, etc.

5. INTERPRETATION

See Section A.3. for further details of personal services needed to interpret geologic resources at Dinosaur.

Non-personal interpretive services about geological resources should be initiated. Interpretive wayside signs for select geological areas can reduce vandalism, theft, and ignorance. One or more trails with geological and earth history themes should be developed and signed. None presently exist in the monument -- a park that has some of the most significant and geological resources in the Service. Slide sets showing geological features and research activities need to be developed for teachers and visitors. Geological protection messages should be placed in appropriate park handouts and publications. Temporary exhibitry is needed to allow for the development of exhibits about current discoveries. This will allow the visitor to know about current work as it goes on, not several years down the line when permanent exhibits are overhauled. This sense of immediacy is a powerful and exciting tool for building interest in and appreciation for the resource.

A present there is a strong need for a good, easy to understand popular book on the geological history of Dinosaur. There is also a need for a river runner's guide which will highlight the geological resources seen in Dinosaur's river canyons. The one sheet USGS geological map of the monument is currently out of print and USGS does not plan to reprint it. The Service or the Dinosaur Nature Association should look into purchasing the plates and reprinting it, especially as it will be decades before it will be out-of-date. This was a popular sales item when it was available.

6. PLANNING

There is a need for improved interpretive planning relative to geological resources. Geology is a technical field which presents a challenge to staff to interpret new discoveries through both personal and non-personal services. Interpretative innovations are needed. Staff should investigate how geological resources are interpreted in other parks and should utilize outside specialists in interpretive training and planning. Funding is needed for travel to other NPS units interpreting geological resources and for attendance at appropriate professional meetings which may address educational and interpretive aspects of earth history.

7. PROTECTION

At present, protection needs for geological resources are restricted to geological resources in the context of a paleontological locality (see: VI. Protection in PALEONTOLOGICAL RESOURCES: OVERVIEW AND NEEDS). The development of a protection program for geological resources will follow the identification of resources in the Geological Resources Needs Assessment (see II. RESEARCH above).

F. GEOGRAPHIC INFORMATION SYSTEM ISSUES

1. HARDWARE AND SOFTWARE

DINO has two large development areas separated by 40 miles and one state line. Cultural, biological resources, and fire management divisions are located in Headquarters while paleontological resource management resides in the Quarry VC. Locating one GIS system in either area would not fill the GIS needs of those divisions in the other area since GIS requires ready access to be useful.

Therefore, the DINO GIS Plan (draft) recommends that 2 GIS stations be maintained. The one housed in Headquarters will be a UNIX based work station. This system will be considered the main system and

will contain all GIS data from all divisions. A digitizer, color screen copier (ink-jet plotter), and pen plotter will be included in this system. The paleontology staff will maintain a less powerful DOS based GIS system on a stand-alone PC. A duplicate data base of that information necessary to manage paleontological resources will be stored on this system.

In order to exchange data with the BLM, DINO will need to purchase some type of compatible hardware. BLM should be contacted at the time of purchase to see what hardware it is currently using.

RMR has proposed DINO as a GIS hub for smaller NPS units in the area. The UNIX system would be powerful enough to handle the added data bases.

Computer hardware of this caliber is very susceptible to AC power problems such as powerline noise, voltage fluctuations and power outages. Though the computers presently in use can tolerate the condition of the power supply in the HQ building, the UNIX work station may not. WASO/Denver support staff suggests a thorough evaluation of the proposed power system be conducted before hardware is purchased. Power conditioning equipment such as spike protectors, line filters, power regulators and stand-by power systems can be purchased, with cost dependent on the amount of protection needed.

GIS technology is only valuable if it is used. The ability to access GIS is the key to making it a useful tool. Maintaining these 2 GIS stations would fill the following needs:

1. Provide DINO with a GIS system powerful enough to meet its foreseeable GIS needs.
2. Provide DINO with a GIS system powerful enough to meet the needs of other parks were DINO to serve as a multi-park node.
3. Allow daily access to the UNIX GIS system for Park Management, Resource Management, Archeology, HQ Visitor Protection, River Management, HQ Maintenance, HQ Interpretation and Administration.
4. Allow daily access to the DOS GIS system for Paleontology.
5. Would physically locate the UNIX based GIS system which requires technical maintenance in the same building with the park's largest concentration of computers to maximize the use of one computer manager.

2. DIGITIZED DATA

The data needs of DINO are presented in Table __. In addition, DINO needs to purchase or have digitized all digital elevational models (DEM) for the entire park and adjacent quadrangles. Digital Line Graph (DLG) data such as hydrology, transportation, and boundaries must also be secured. National Wetlands Inventory needs to be generated from 1:62000 from color infra red photographs, but is of lower priority than DEM or DLG data.

V. CULTURAL RESOURCE BASELINE

CULTURAL RESOURCE DOCUMENTATION CHECKLIST

TITLE	CURRENT AND APPROVED	INCOMPLETE: NEEDS REVISION OR UPDATING	NEEDED
PLANNING DOCUMENTS			
Preauthorization and Authorization	X		
Statement for Management (SFM)	X		
Outline of Planning Requirements (OPR)	X		
General Management Plan (GMP)	X		
Development Concept Plan (DCP)			X
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

CULTURAL RESOURCE DOCUMENTATION CHECKLIST

TITLE	CURRENT AND APPROVED	INCOMPLETE: NEEDS REVISION OR UPDATING	NEEDED
BASIC CULTURAL RESOURCE DOCUMENTS (cont.)			
Ethnographic Overview & Assessment		Not needed	
Ethnographic Oral Histories & Life Histories		Not needed	
Ethnographic Program		Not needed	
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		Not needed	
Collection Management Plan	X		
Collection Storage Plan	X		
Collection Condition Survey			X
Cultural Landscape Report (CLR)			X
Ethnohistory			X
Exhibit Plan		Not needed	
Historic Furnishings Report		Not needed	
Historic Structure Preservation Guide (HSPG)			X
Historic Structure Report			X
Social Impact Study		Not needed	
Special History Study		Not needed	
Traditional Use Study		Not needed	

VI. CULTURAL RESOURCES STATUS

A. ARCHEOLOGIC RESOURCES

Archeological sites within the monument are numerous and significant. The national significance of most of the sites has not been evaluated. Between 1921 and 1984, 364 sites were identified. Out of those sites 31 lack location and descriptive information. Out of the 333 remaining sites 326 were not evaluated, nor were they documented in accordance with the Secretary's standards. The 87 sites that have been documented between 1988 and 1990 have been properly documented and evaluated. Many of them meet the criteria for placement on the National Register of Historic Places (NRHP). The presumption is that many of the monument's sites are significant. The Regional Archeologist has commented that the archeological resources within the monument are the least disturbed of any in the region. Obviously since the documentation of the 364 sites mention earlier was little more than identifying location and site type, it is difficult to state with certainty the condition of all archeological sites. Even so, we feel that most sites are in good to fair condition because of the undeveloped nature of the monument and the low level of cultural impacts present. Many sites that have been documented over the last three years are in a condition to provide useful scientific information if tested or excavated. For most of the known archeological sites the level of impacts are low. There are some sites with severe impacts, but they are in the minority. Cultural impacts observed are looting, lithic collection piles, trampling by livestock. Impacts to rock art include touching, chalking, latex impressions, rubbings, graffiti, and bullet holes. Natural impacts for the most part are erosion and the action of burrowing rodents. Archeological site survey's were done in the 1960's by Dr. David Breternitz of the University of Colorado, and claim to have covered 50% of the monument. However, archeological work over the last three years has shown that Breternitz's survey was not thorough and the sites were not well documented. Breternitz's work was in fact a reconnaissance rather than a survey. In Sand Canyon, one small area Breternitz surveyed, 25 new sites were found. Therefore, we estimated that only 1 to 2% of the monument has been adequately surveyed and sites properly documented.

B. HISTORIC STRUCTURES AND SITES

Historic structures and sites (135 structures) are well documented. Historic structures are the one cultural resource in which we have good baseline information. All structures have been evaluated by a professional historian as to their significance and eligibility for placement on the NRHP. Five sites are on the National Register

and all other sites have been determined to be ineligible. There is an approved Historic Resources Study (1985) for the monument. All historic structures and sites are of local significance. Many structures (38%) are in poor condition having moldered to the point where stabilization is not practical. The major impacts causing poor structure condition is weather. Most of the structures are of log construction, without a foundation and simply decayed into total disrepair. The impact of intruding moisture has been severe. All National Register structures and a few other structures that have interpretive potential need Stabilization Assessments followed by structure stabilization and inclusion in the Cyclic Maintenance program to receive routine preservation maintenance. In 1985 the monument's Historic Resources Study and survey was completed. Ninety percent of the monument was surveyed for historic structures and sites.

C. MUSEUM COLLECTIION

Museum collection numbers 33,000 objects (18,900 archeology, 0 ethnology, 240 history, 0 archives, 7,600 biology, 5,000 paleontology, 46 geology). The condition of all the objects in each category is generally fair to good. The one exception are "archival" or historical documents which need to be examined for possible treatment and storage needs. They include: 1) paper (original maps, field notebooks, publications, correspondence, typed preparation notes, etc.), mostly from the Carnegie excavations, 2) original linen maps, 3) oral history interviews on reel to reel and cassette tape, 4) black and white negatives and prints and color slides, in a range of sizes, 1 1/2 X 1 1/2, 2 X 2, 4 X 4, and 5) glass lantern slides. Their condition is fair and may soon become poor. The types of impacts on paleontology objects stored in the Quarry laboratory include uncontrolled environment, dust, and unsecured storage area where all monument staff have open access. In addition the storage area is located within the paleontology laboratory where specimens are prepared. Large objects are moved around the lab and dust is generated during preparation, both of which contribute to unacceptable storage conditions. The small and valuable paleontology objects are stored in locked cabinets. There is an intrusion and fire alarm system and fire suppression system at the Quarry, but this system does not work 100% of the time. Archeological and biological objects are stored in the Headquarters basement. The storage environment is not controlled, but remains fairly constant and meets standards. The headquarters collections storage room is locked and objects are stored in locked cabinets that meet NPS specifications, but some open rack storage exists. Headquarters is protected with an intrusion alarm and fire alarm, but has no suppression system. The archeology collection contains vegetal specimens, but thus far insect infestations have not occurred. An increasing impact

affecting all of the museum collections, both at Headquarters and the Dinosaur Quarry, is the lack of appropriate climate controlled space to store all the objects. Accessioning of all objects is current. Over the last three years there have been cataloging backlogs of 3 to 5,000 objects each year. Although cataloging has been completed all necessary work on the specimens has not been completed. There are several thousand specimens at the National Ecology Center which are catalogued, but do not have the DINO accession and catalog number on their labels. The same is true for several thousand plants from the Sensitive Plant Survey. Some of these specimens include materials of endangered species. In addition there are no loan forms for thousands of those same plant and animal specimens in outside repositories. Not all of the collection is on ANCS - there are several thousand specimens catalogued by typewriter in the 1960's and 1970's that need to be entered into the ANCS in order for the system to be utilized to its fullest. The Scope of Collections Statement (1986) is current, but needs revision and there is an approved Collections Management Plan (1987).

D. CULTURAL LANDSCAPE

The monument's canyons, variety of habitats and range lands are a cultural landscape that in this region is diminishing. Within the monument the cultural landscape is in good condition except for the range land. In this instance overgrazing and the exclusion of fire has created a landscape dominated by sagebrush and juniper. Available evidence indicates that sagebrush and juniper were present in presettlement days, but to a lesser extent. The current prescribed burning program is rectifying this situation. The landscape at most significant historic sites (Josie Morris Ranch and Chew Ranch) have been altered by the intrusion of access roads and parking, but retain their essential character. There has been no survey or reports dealing with the monument's cultural landscape.

E. ETHNOGRAPHIC RESOURCES

There are no known ethnographic resources at the monument. The Ute people were moved to reservations prior to settlement by Mormons. Historical and ethnographic documentation of Ute occupation and use of the monument is not known. There have been no ethnology studies done for the monument. There is, however, the possibility that when contacts with the Ute tribe are expanded ethnographic information may come to light.

VII. CULTURAL CONTEXT/THEMES

Culturally, Dinosaur National Monument has been influenced by both the Great Basin, Northwestern Plains and Colorado Plateau cultures. Many manuscripts have been produced which address an overview of archaeological background information and cultural chronology thought to be relevant to areas adjacent to Dinosaur National Monument. A cultural chronology for Dinosaur National Monument and the surrounding areas was developed by the Monument archaeologist in 1989 (Truesdale 1989:6-22). This chronology was drawn from Eckles and Hauff (1983:17-31), Fawcett et al. (1981), Grady (1984), LaPoint (1987), LaPoint et al. (1981), Shroedl (1985:16-21), Shutler (1983). These references include the Northwest Colorado Prehistoric Context written by James Grady in 1984 for the Colorado Office of Archaeology and Historic Preservation. Grady (1984) also addresses research problems, data gaps and future needs to improve the prehistoric context of the Dinosaur National Monument area.

Context	Property Types
Paleoindian	archeological sites, museum objects
Early Archaic	archeological sites, museum objects
Middle Archaic	archeological sites, museum objects
Late Archaic	archeological sites, museum objects,
Late Prehistoric	archeological sites, museum objects, rock art
Historic	archeological sites, museum objects, rock art
Exploration to 1910	exploration routes
Early settlement 1850-1880	structure sites
Ranching to 1900	structure sites
Development of trails and transportation	rivers, Mantle road, Outlaw Trail
The outlaws 1870-1910	structures, Outlaw Trail
Mining & lumbering	mines, roads

Ranching after 1900	structures, farm equipment, roads, irrigation ditches, oral histories, "archives"
Conservation and federal resource development after 1891	None
Water resource development after 1900	dam sites, dam survey marks, USGS camp site, "archives"
Scientific exploration and monument development after 1900	Green River, Powell camp sites, Carnegie quarry site

VIII. OVERVIEW OF CURRENT CULTURAL RESOURCES PROGRAM AND NEEDS

In 1986 a Cultural Resource Management Specialist was appointed from the monument staff to be the "key person" to handle inquiries from region concerning cultural matters. This appointment was a collateral duty to an existing full-time job. A Draft Cultural Resource Management Plan was completed (but not submitted for approval) in 1986 and became the basis for Cultural Cyclic Maintenance requests. Funding for a Rock Art Documentation Program (cultural cyclic) was approved, a temporary Park Archeologist hired, and rock art documentation begun in 1988. The Cultural Resource Management Specialist devotes 10 to 15% of their time to cultural resources management. Funding for this position is out of the Division of Interpretation. Funding for the temporary Park Archeologist is out of Cultural Cyclic Maintenance. The archeologist frequently conducts 106 clearances for park construction and routine maintenance projects. Site documentation forms and professional reports of findings are written for the new sites found as a result of the 106 clearance work. As the rock art sites are documented, the park archeologist establishes a monitoring program for each site. The past three years are the first time the monument has had a position dedicated to cultural resource management and has made progress toward surveying and monitoring cultural resources.

The curatorial program is managed by the Park Curator (Paleontologist) as a collateral duty. A fossil preparator assists the Curator with artifact cataloging, ANCS entries, and data base management. The Archeologist curates the archeological specimens. The two fossil preparators prepare fossil specimens and assist with their storage. Considering the number of new specimens acquired each year and the lack of a full time curatorial staff and proper storage, the collections are well managed and in good shape.

In the past park interpreters included talks and walks in their interpretive program schedule designed to enlighten visitors about the park's cultural resources and their fragility. In addition, the presence of uniformed interpreters at sites provide a deterrence to would-be vandals, or collectors. In recent years, budget constraints precluded such interpretive activities. Several interpretive wayside media are in the planning process for four archeological sites and four historic structures. Printed media (publications) are also planned that deal with the cultural resources of the park and will be sold by the cooperating association. An Interpretive Prospectus which addresses cultural resources is presently in the draft stage. The Dinosaur Nature

Association funded the stabilization and development of interpretive signs for Mantle Cave prehistoric structures, and interpretive signs at Deluge Shelter, Swelter Shelter archeological sites and signs at the Morris, Chew, Baker, and White historic sites.

Visitor protection personnel, 4 full time patrol rangers, have the primary responsibility for patrolling cultural sites, detection of violations, and intervention and investigation. During the summer months they are assisted by a varying number of seasonal protection rangers. Because of continuing budget constraints few cultural sites benefit from regular patrols and monitoring. During recent years, ARPA funds were received for a seasonal ARPA ranger whose primary responsibility was the monitoring of cultural sites. This was a welcome assistance.

This section is organized by identifying the system-wide cultural resource issue. The current program and future needs that relate to the issue are described under project statement subheadings.

A. DOCUMENTATION BY SYSTEMWIDE CULTURAL RESOURCES ISSUES

1. ARCHEOLOGICAL SURVEY AND INVENTORY, INCLUDING ARCHEOLOGICAL IDENTIFICATION AND EVALUATION STUDIES, OVERVIEW AND ASSESSMENTS

Over the last 25 years, few sites have been added to the list of 364 archeological sites discovered between 1921 and 1984. With the arrival of a temporary Park Archeologist, professional 106 clearances have been conducted over the last 3 years and 87 new sites discovered and documented. The Archeologist's primary duties were documenting rock art sites and setting up a rock art monitoring program. Although projects requiring 106 have necessitated systematic surveys of project areas, no park wide systematic survey for archeological sites will be done by the Archeologist.

The most basic information needed by the monument to protect and manage it's archeological resources is missing. We simply do not know what archeological resources are in the park, nor where they are located. The monument knows the location of 451 sites on 2% of the monument's acreage. Of those 451 sites 31 lack location and descriptive information. Out of the remaining 413 sites 326 lack site documentation that meets the Secretary's Standards and have not been evaluated as to their eligibility to be placed on the National Register of Historic Places (NRHP). The remaining 87 sites have been properly documented and evaluated since 1988.

The lack of an adequate inventory of sites affects monument resources and mandates in the following ways:

1. Compliance with Section 106 of the National Historic Preservation Act is more difficult. It hinders the monument's ability to draft a PMOA. Each project that has the potential of having an adverse effect requires a site survey and Assessment of Effect form. Consultation with Native Americans is more difficult since the monument does not know which sites are related to certain Native American groups.

2. Some sites are being lost to erosion and vandalism because their existence and condition is not known. Since only 2% of the monument has been adequately surveyed the severity of this problem is unknown.

3. The monument's mandate to protect sites is only partly fulfilled. Obviously the monument can't protect and develop management strategies for resources that are unidentified. Developing an efficient protection plan is impossible since the significant sites are not known and protection patrols and interpretation can't be targeted to these sites.

4. The establishment of a monitoring program is impossible since only 87 sites have appropriate documentation.

5. Interpretation of Native Americans is hindered because basic data concerning these people is not known. This basic data would be provided in part by a complete monument survey.

The monument contains many unexcavated sites that are in good condition. It is an area where Great Basin, Colorado Plateau, and Plains cultures interface and their prehistory spans 12,000 years. The monument's varied and productive habitats allowed prehistoric bands of people to utilize resources, eliminating the necessity to range far and wide to obtain resources. For these reasons the monument can contribute significantly to the scientific knowledge of the region's prehistoric past. Until basic baseline information on the existence of sites is obtained, the monument's prehistoric cultural resources will not contribute to the fund of knowledge, nor can they be properly protected from erosion, construction, and vandalism.

a. ROCK ART DOCUMENTATION & ESTABLISHMENT OF A MONITORING PROGRAM

An incomplete field survey of Monument lands during the summer field seasons of 1963-64 by David Breternitz and students from the University of Colorado, Boulder (Breternitz 1965) revealed 30 rock art sites. A field site sheet and limited photographs document

these sites. From this data together with some additional field work by Robert J. Burton 38 rock art sites were known as of 1985.

The documentation of the known rock art sites was poor. There were no completed up to date state site forms for any sites. There were no scale drawings or site maps. There were some photographs for many sites, but not all. Some of the rock art sites receive heavy visitation and resultant erosion of surrounding site soils, littering, touching, and vandalism. Even so, monument sites are considered to be "pristine" when compared with southern Utah sites. Sites are also experiencing natural impacts from digging rodents, livestock, abrading vegetation, bird droppings, surface runoff, wind abrasion, and light. Impacts, whether natural or human, are experienced by all the monument rock art sites.

Mitigation of the ongoing loss of rock art is an immediate and critical need. In 1988, the monument received cultural cyclic maintenance funding to document rock art sites and establish a rock art monitoring program. A portion of these funds was used to hire a temporary Archeologist whose primary responsibility was to assist the rock art documentation team and establish the monitoring program. The documentation work was begun by the Midwest Archeological Center that year. MWAC also returned in 1989. Areas of the monument likely to contain additional unknown rock art sites were surveyed and a total of 70 rock art sites is known as of 1990. In 1990, the monument Archeologist continued with the field documentation work. In addition, a contractor was selected to complete scale drawings of selected rock art sites.

b. SECTION 106 CLEARANCE FOR ALL DEVELOPED AREAS & WRITE A PMOA

The highest recurring need is to comply with Section 106 of the National Historic Preservation Act. All roads and developed areas within the monument, except for the Echo Park Road, have not been systematically surveyed for prehistoric sites. Once the developed areas are surveyed the park can develop a Programmatic Memorandum of Agreement with the Utah and Colorado State Historic Preservation Officers. A PMOA will facilitate most 106 clearances since ground disturbance usually take place in the developed areas.

Throughout the 75 year history of the monument there has not been a permanent Archeologist on the staff. This is most evident by the lack of information the monument has about its archeological resources and in the past, the number of ground disturbance projects that were completed without proper Section 106 clearance. In addition, the monument is as much a cultural park as it is a paleontological, geological, scenic, or river running park. As has already been described, the archeological resources of the monument are significant and can provide the answer to key research

questions. In 1988 a temporary Archeologist was hired to manage the rock art documentation project and establish a rock art monitoring program. It was not until a temporary Archeologist was hired that the benefits of having an archeologist on staff became evident. The completion of Section 106 clearances and the survey of the developed areas of the monument can best be done by a staff archeologist. In addition, the archeologist can maintain the archeologic site base maps, historic site base map, and the Cultural Sites Inventory. The archeologist can take the lead in Native American consultation between the monument and the Ute tribe. The archeologist can assist the interpretive division develop publications that deal with cultural resources and Native Americans and keep the information presented to the public accurate. Our present experience with an archeologist in the park has also shown that clerical assistance for this position would be desirable. Without clerical assistance, the archeologist would be encumbered by the need to do their own final preparation of reports, professional papers, site forms, Assessment of Effect forms, the PMOA, entries onto ANCS, and filing. In short, a permanent archeologist would manage the significant archeologic resources, that has been ignored until 1988, and a clerical position would manage the copious amount of paperwork and computer data entry that is associated with the program.

c. ARCHEOLOGICAL INVENTORY STUDY

The most critical long range need is a systematic and comprehensive inventory of archeological sites within the monument. Once this is completed, the monument can take deliberate steps to protect sites through mitigation, interpretation, and law enforcement efforts. Both of these critical tasks would be done, or facilitated by a much needed permanent archeologist. The establishment of a permanent archeologist position at the monument is as much a critical need as is the need for an inventory of sites.

d. ARCHEOLOGICAL EVALUATION STUDY

Upon completion of the above inventory studies, the next logical step is to determine the significance of the archeological sites. The significance of the archeological sites in the monument is not known. Specific determinations of significance have not been made using National Register criteria. The lack of knowledge regarding the significance of sites makes it impossible to set priorities for monitoring and patrol efforts. Completion of the Archeological Inventory Study will identify sites that have the potential for nomination to the National Register of Historic Places (NRHP) and will also indicate what sites need further testing. Execution of an Archeological Evaluation Study will require testing of approximately 5% of the sites in order to make a determination of

eligibility and obtain the information necessary to write site and district National Register nominations.

e. REVISE ARCHEOLOGICAL OVERVIEW AND ARCHEOLGICAL ASSESSMENT

Once the inventory and evaluation studies are completed, the Archeological Overview and Archeological Assessment need to be revised. At that point the monument will know the extent and significance of the monument's cultural resources, but will face the question, "Where do we go from here?" In other words, the monument will need a plan to guide future research. An Archeological Overview and Assessment will summarize the existing archeological data (survey and evaluation information), and evaluate that data. This is the first step in determining the need for and design of future studies.

The most critical archeological resource management need is to gather baseline information on the monument's sites (inventory studies). This basic need has been broken down into four smaller and manageable projects. Of these the most critical is the documentation of rock art (Rock art documentation and establishment of a monitoring program) because it is the most threatened resource. Secondly, and of equal importance is meeting Section 106 requirements (Section 106 clearance for all developed areas and write a PMOA) and the establishment of an archeologist and clerical positions to do the work (Increase professional staff). Thirdly would be the inventory of sites in undeveloped areas of the monument (Archeological Inventory Study). With the completion of the inventory of archeological sites in the monument their significance most be determined and sites nominated the National Register (Archeological Evaluation Study). These studies would provide the monument with basic baseline information, but we will, at that point, need guidance about the need for future research studies (Revise Archeological Overview and Archeological Assessment).

2. INCOMPLETE CATALOGING OF MUSEUM COLLECTIONS (ANCS)

Cataloging and curation of archeological objects collected at new sites is completed by the archeologist. Curation for paleontological and biological objects collected during the year is coordinated by the Park Curator. Cataloging and curatorial work is funded by the Division of Interpretation and the Park Curator duties is a collateral assignment of the Paleontologist. The Paleontologist is assisted by one fossil preparator. Curation is increasingly taking more time as the collections increase. The full range of curatorial activities takes place almost on a daily basis. These include accessioning, cataloging, object preparation and storage, and managing the files and loan forms. The Park Curator must follow-up

with researchers on their collected specimens to complete accessioning and cataloging. The Park Curator also manages the paleontology library which is extensive and contains many rare and out of print publications. An unusual feature of the collection is the 50 foot high and 150 foot long tilted "cliff" face that bears 1,600 reliefed fossil specimens. These are part of the collection and continue to be discovered, reliefed, curated, and "stored" in place on the cliff face.

The monument's museum collections are valued at over $2,500,000. As of December 1989, collections contained 33,000 items under 14,000 catalog records stored both on site and in outside repositories. The collections contain paleontological type specimens, archeological objects from significant Archaic sites, and baseline records of rare, endemic, and common plants of the monument. The collections are a resource which exist for future research in several areas of scientific study. If baseline collection of park resources continues, and that is likely, the collections will expand each year creating an ever increasing cataloging backlog which the current staff cannot cope with.

a. INCREASE PROFESSIONAL STAFF

The establishment of a permanent Museum Aid position would allow the monument to shift the curatorial duties from the Paleontologist and his staff to this position. This would insure the completion of proper storage area environment monitoring, formal collection condition surveys, and maintain housekeeping standards. The position would organize the "archives" or historical document files, administer loan requests for photographs, slides, films; maintain the park libraries, catalog onto a computer the publications in the paleontology library. The position would handle accessioning and cataloging of new specimens and could, keep abreast of the current ANCS workload, and over time, eliminate the ANCS backlog. Besides meeting NPS-28, NPS-6, and Museum Guideline standards, the position would enhance the cultural and natural resource management program by freeing researchers and preparators from curatorial duties allowing them to spend more time on field and lab work that protects those resources.

b. MICROFICHE ARCHEOLOGICAL FIELD NOTES AND REPORTS HELD BY THE UNIVERSITY OF COLORADO

The Monument museum collections currently include over 1,200 archeological artifacts, primarily the products of a 1963-64 surface survey and 1964-65 excavations by the University of Colorado, Boulder, under the direction of David Breternitz. The artifacts, together with field notes and photographs, were transferred to the Monument in 1977.

Collections by Breternitz are not the most extensive known from the Monument. The location of an estimated 2,500 artifacts from post-WWII excavations at the University of Colorado, Boulder, has been confirmed. Archeological collections were made here as early as 1933 and continued through the 1940s. The location of these early collections is unknown. More significant than the absence of actual artifacts is the absence of data which they represent. A long term need is to locate the field notes from these early excavations and copy them (microfiche) for the monument site files, which are part of the monument's museum collections.

The highest critical need for museum collections is a permanent Museum Aid position with this position should come an ANCS computer. The extent and variety of the collections and the ever increasing addition of specimens has caused the collateral duty of curation to become a full time job.

c. PROVIDE DOCUMENTATION OF QUARRY EXCAVATIONS

The park has little documentation of the early quarrying activities (1909-1953) at the Dinosaur Quarry. Information is needed on the history of the excavations, specimens collected, present repositories of such specimens and their associated catalog data, involvement of museums in developing the present quarry building, WPA activities, etc. Copies of correspondence, field maps, notes, photographs, journals, etc. related to the early quarrying activities are needed. This will provided needed baseline data for staff and outside researchers on the quarry which the NPS is still excavating.

d. PHOTODOCUMENTATION OF MUSEUM COLLECTIONS

Accurate description is a critical component of a museum catalog record. Narrative description alone is often insufficient to describe a specimen. Photography and narrative description are complementary and often both are required for a quality description. Some reasons to photograph are:

1. Aid in description (especially with complex objects),
2. Record condition,
3. Aid in recovery, if stolen or lost,
4. Aid in research (photo can be used for initial research, eliminating the need to handle the object),
5. Record dimensions without measuring by using a scale in the photograph.

The DINO museum collection contains about 33,000 objects and specimens. It is estimated that approximately 7,000 of these items would be suitable candidates for photography, With some objects

needing multiple photographs for adequate documentation, approximately 9,000 photographs will be needed. At present, virtually no photographic documentation of the collection exists. Current staffing levels, budgets, and work loads are such that permanent staff can not undertake this project.

3. NEED FOR ETHNOGRAPHIC OVERVIEWS AND ASSESSMENTS, ORAL HISTORIES AND LIFE HISTORIES

a. AMPLIFICATION OF ORAL HISTORY PROJECT

The oral history collection includes 60 titles, 47 oral history tapes dating from 1959 together with 13 paleontology history tapes. Of this group of 60 tapes, only 17 have been transcribed. The 60 tapes do not exhaust all potential resources. Of four major history groupings, the early Dinosaur Quarry (1909-1924), settlers (1905-1935), WPA activities (1933-1938), and the Echo Park Dam controversy, none have been completely covered. The dates of all but the fourth category make it imperative that the history be recorded very soon before it is irretrievably lost.

b. ETNOHISTORY

The Ute and Shoshone people are the historic tribes that were in and around the monument. Presently the monument's interpretive program does not interpret these peoples because we do not have the information available to develop accurate activities. The monument's contacts with the Ute tribe, thus far have been minimal. We have completed two Native American consultations with the Ute tribe over that last three years, but that is it. It is quite possible that within the monument there are resources or sites, that are of value and significance to the Ute people. However, we do not know that. An Ethnohistory for the monument would provide the information necessary to improve the interpretation of Ute and Shoshone people, identify resources or sites within the monument that are important to these tribes, and increase the cultural awareness of management toward the local Native Americans.

4. NEED FOR HISTORIC PRESERVATION GUIDES

Presently no stabilization assessments, nor preservation guides have been written following the 1985 Historic Resources Study and the listing of five sites to the National Register of Historic Places. The maintenance division does not have the requisite documented guidance (plans) to carry out preservation maintenance. If maintenance had the plans for guidance, the monument could not maintain the log structures because of the lack of man power and supplies to do the work. Cyclic maintenance funding requests have been submitted for stabilization assessments and preservation

guides for four National Register sites, but thus far they have not been funded. Meanwhile, the National Register structures continue to deteriorate due to neglect and intrusion of moisture.

a. STABILIZATION ASSESSMENT AND PRESERVATION GUIDE FOR NATIONAL REGISTER STRUCTURES

There are five National Register sites within the monument containing a total of fifteen structures that are deteriorating from the intrusion of moisture. In the case of the Dinosaur Quarry building, serious stabilization problems exist from water intrusion into the expansive soils in which the building foundation rests. The Josie Morris cabin's sill logs have deteriorated from ground moisture and the entire structure has shifted significantly. The funds necessary to stabilize the Morris cabin would be significant and probably prohibitive. To prevent the other fourteen National Register structures from reaching the deteriorated condition of the Morris cabin, immediate steps should be taken to write Stabilization Assessments and Preservation Guides for all the structures in order to initiate stabilization work.

For those structures that will be stabilized, a Stabilization Assessment and Historic Preservation Guide should be developed. Funding has been sought for stabilization work and each stabilized structure placed in the cyclic maintenance program to receive periodic preservation maintenance.

b. INCREASE PROFESSIONAL STAFF

Maintenance personnel in each district should receive training on preservation maintenance, especially for log structures. The maintenance funding for supplies and materials to undertake preservation maintenance should be increased. After all structures are stabilized, an additional 2.0 MY of maintenance personnel dedicated to preservation maintenance will be needed.

Each stabilized structure should be evaluated for its use in the Historic Leasing Program for alternative park use. Occupied historic structures, appropriately used, will last longer and receive better preservation maintenance.

The highest critical need is the development of the Stabilization Assessment and Preservation Guides. With these in hand the monument can begin to take steps to stabilize and maintain the structures. The next critical need would be cyclic maintenance funding to stabilize all the National Register buildings. Following stabilization, maintenance funding and personnel should be increased in order to carry out preservation maintenance.

5. NEED FOR HISTORIC RESOURCE STUDIES AND ADMINISTRATIVE HISTORIES

The monument is fortunate to have a current Historic Resources Study (completed in 1985). As a result, all of the historic structures in the monument have been evaluated for inclusion to the National Register of Historic Places.

The existing administrative history was written by Dr. Richard C. Beidleman initially under a $1500 contract in 1961-62. Neither the contract period, nor the amount proved adequate; however, Dr. Beidleman continued to research and write through 1967, at least in part on a volunteer basis.

The resulting 235-page history reflects its being written chapter by chapter and over an extended period. It does not flow chronologically.

The history is at minimum 35 years out-of-date. The history of the Expansion of the Monument needs to be carried beyond 1935 to July 1938. The Echo Park Dam controversy needs to be expanded to include the last six years. The administrative history in general needs to be updated to include changes in the location of park headquarters, boundary revisions, interest in national park status, the development of river running, and other events since 1938.

6. NEED FOR COLLECTIONS MANAGEMENT PLANS, COLLECTION STORAGE PLANS AND COLLECTION CONDITION SURVEYS

In November of 1987, a Collection Management Plan for the monument was completed and it agreed with the 1985 General Management Plan's recommendation for a new curatorial storage building. As a result a 10-238 was submitted for the construction of a curatorial storage building. In 1990, the 10-238 was revised to include the preparation of a Collection Storage Plan.

Museum collections are stored at Headquarters and the paleontology laboratory at the Quarry. Open rack shelves and museum storage cabinets in the laboratory take up much of the laboratory area and interferes with preparation work. The present storage areas are inadequate in size and lack environmental controls, venting of radon gas, security, and fire protection. The lack of storage space is already causing the paleontology operation to forego the excavation of large threatened fossil specimens. This leaves those unexcavated fossils at risk.

A 10-238 has been submitted to build a new museum collection building. However, the cooperating association is willing to fund the architectural and engineering design for a storage building and may be willing to fund the construction of the building in FY-92.

A Collection Storage Plan is needed to design this new museum storage building. Cultural Resource Management Guidelines, NPS-28, recommend completing a storage plan before construction of a museum storage facility. A recent call to the Washington office of the Associate Director of Cultural Resources confirmed that a Collection Storage Plan must be written prior to the design and construction of a new storage building.

Once the design for the collection storage building begins a Collection Storage Plan should be completed to guide the storage building design.

The construction of a collection storage building is a critical and immediate need. The architectural and engineering design of this building will be done in FY-91. The completion of a Collection Storage Plan is critical to the proper planning of the building and must be started immediately.

7. NEED FOR SPECIALIZED STUDIES FOR UNIQUE OR COMPLEX MANAGEMENT ISSUES

For cultural resources the critical studies needed are the inventory and evaluation studies mentioned earlier. However, there are two specialized studies that should be done that would greatly assist the completion, thoroughness, and accuracy of these studies.

a. QUATERNARY SOILS STUDY

A Quaternary soils study is needed to identify the location of Holocene and Quaternary soils within the monument. A geoarcheological study along the Echo Park Road, completed in 1988, revealed the monument has Quaternary soils. This information raises the possibility that paleoindian sites may exist in the monument. Knowing the location of such soils will aid archeologists in locating paleoindian sites and will greatly assist in paleoenvironmental reconstruction of the monument's recent past.

b. DENDROCHRONOLOGY STUDY

The monument's cultural chronology lacks identification of important dateable events and our understanding of the paleoenvironment is poor. This results in an inadequate presentation of prehistoric human events within the monument to the public and hinders researcher's ability to derive answers to research questions and formulate research strategies.

Some trees in the monument are suspected of being 1,000 years old and have the probability of yielding a tree ring sequence which may reach back 2 to 3,000 years. Thus, a dendrochronology study would

provide a data base from which to date wood products and construction material from archeological sites and reconstruct the occurrence of wet and dry periods during the last several thousand years.

To this date, only one site in the monument has had a dendrochronologic study conducted from collected samples. The samples from 42UN1103 were sent to the laboratory of Tree Ring Research at the University of Arizona and calibrated from their data base.

The Quaternary study is more critical than the dendrochronology study. Until serious inventory studies get underway, there are other projects which are more critical than these.

8. NEED FOR CULTURAL LANDSCAPE REPORT

The monument has cultural landscapes that are associated with Native Americans, initial exploration of the monument, early cattle ranches, turn of the century homesteads, and the Dinosaur Quarry. The monument does not have anyone on the staff with the knowledge to evaluate these landscapes, research their historical appearance, or recommend management strategies to protect the landscapes.

Before management strategies are recommended, management must decide which landscapes will be managed to perpetuate cultural characteristics, and which landscapes will be managed to perpetuate natural, or presettlement landscapes. Any landscape could be managed to achieve either objective, but each objective is probably exclusive of the other. A Cultural Landscape Report is needed to assist management with its decisions and guide the management of the landscapes. Fire management and grazing management will have a direct impact on cultural landscapes. The Cultural Landscape Report, Fire Management Plan, and Resource Management Plan as it relates to grazing, should all be synchronized to achieve agreed upon results in managing landscapes.

B. TREATMENT

1. INADEQUATE PRESERVATION MAINTENANCE PROGRAMS INCLUDING STABILIZATION AND CYCLIC MAINTENANCE

a. COMPLETE STABILIZATION WORK ON NATIONAL REGISTER STRUCTURES

The first known attempt at stabilization of a cultural feature at the monument was the construction of a free-standing roof over the Josie Morris cabin in the late 1970's. Today's wisdom suggests that the roof may be holding moisture in the building more than it is keeping moisture out, contributing to its rapid deterioration.

Sometime in the past, the Douglass rock shelter received some minor stabilization work. It was not until 1986 that requests for cultural cyclic maintenance projects (Type 38) were submitted from the monument. Since then, one request, a rock art documentation and monitoring project, has been funded out of cyclic maintenance. In 198? and for the last X years, the monument has received cyclic maintenance Type 40 funding for the stabilization and rehabilitation of the Dinosaur Quarry, a National Register building. Moisture entering the soil beneath the building has caused major foundation shifting. The Type 40 money has gone toward completing studies that will determine the source of the moisture and the stabilization measures that must be taken. In 1988 the Dinosaur Nature Association (DNA) funded the completion of a Stabilization Assessment for the prehistoric granaries. The following year, DNA funded stabilization work to the granaries in Mantle Cave. In 1989 the monument obtained 106 clearance to cover the roof of the National Register Chew ranch house with roofing paper as a temporary measure to prevent intrusion of moisture into the structure. This is the only cultural stabilization work that has been done in the monument during its entire 75 year history.

Over the last 20 years, or so, the Josie Morris cabin, a National Register structure, has deteriorated to the point that stabilization would be so extensive, costs would be prohibitive. Our other National Register structures (Chew Ranch complex, Wade and Curtis cabin, Douglass rock shelter, Dinosaur Quarry building) are gradually deteriorating to this same condition. Intervention is necessary or we will lose these historic structures and the interpretive benefits they can bring. Stabilization is a critical need.

b. CYCLIC PRESERVATION MAINTENANCE FOR NATIONAL REGISTER STRUCTURES

Presently there is no cyclic maintenance, or preservation maintenance, done to historic structures, with the exception of the Dinosaur Quarry. A preservation maintenance program is not in place because a Stabilization Assessment for historic structures has not been written, no historic structures have been stabilized, and a Preservation Guide has not been written for structures. Until project numbers 1400-C-010 and 1400-C-016 are completed the lack of a cyclic maintenance and preservation maintenance program for historic structures will continue.

The effect of this situation is the continued deterioration and maybe eventual loss of historic structures in the monument. These structures have interpretive values and potential for alternative uses.

There are a number of archeological sites, granaries, pit houses, possibly rock art, that could receive stabilization work. However, presently there are no identified significant archeological sites that have a critical need for stabilization. The exception to this are the granaries in Mantle Cave which were stabilized in 1989. This could change if significant sites are vandalized or damaged by natural causes. Under those circumstances stabilization of the affected site(s) would become critical.

2. NEED FOR REHABILITATION OR RESTORATION OF HISTORIC AND PREHISTORIC STRUCTURES, AND CULTURAL LANDSCAPES

Rehabilitation and restoration of historic structures is a management goal of the monument. Whether a prehistoric structure or cultural landscapes should be rehabilitated or restored is another question. Presently so little is known about the prehistoric sites of the monument, their significance, and interpretive potential, that we cannot recommend a structure for rehabilitation or restoration. The completion of a park wide Archeological Inventory Study and Archeological Evaluation Study would help the monument determine if restoration or rehabilitation is necessary at some sites. The same is true for cultural landscapes. The completion of a Cultural Landscape Report is the best means the monument has to determine if landscapes need rehabilitation or restoration.

3. NEED FOR MAJOR ARCHEOLOGICAL DATA RECOVERY

In the late 1930's and early 1940's archaeologists Robert Burgh and Charles Scoggin conducted a major excavation of Mantle Cave. In the 1960's archeologist David Breternitz and his students conducted a number of test excavations and three major excavations at Cub Creek, Swelter Shelter, and Deluge Shelter. These early excavations constitute almost the entire data base on prehistoric sites within the monument. In 1981, 42UN1103, a site in Jones Hole, was excavated by Terri Liestman. Liestman's analysis and conclusions indicated that the early interpretations about Fremonts should probably be revised and the artifacts in collections restudied. With the arrival of a temporary Archeologist on the monument staff in 1988, a number of sites have been tested and two Fremont burials excavated. The archeologist's analysis and conclusions has greatly revised the cultural chronology of the area, the origins of Fremonts, and has proven the existence of numerous Archaic and Paleoindian sites. Besides clarifying the cultural chronology, data recovery from tests on sites will determine eligibility to the National Register providing the information necessary to prepare site and district National Register nominations. There has never been an overall plan to guide data recovery in the monument.

Because the General Management Plan calls for little further development, it is unlikely that development projects will generate the need for major data recovery. However, visitor impacts or erosion may threaten sites to the point that mitigation by excavation is necessary and an Archeological Data Recovery Study would be done. This will be difficult to determine because we lack an effective archeological site monitoring program to alert us to such threats. There are areas in the monument which receive high visitor impacts and contain significant archeological resources.

As has already been identified, a critical need is the completion of an archeological identification study (monument survey for sites). When the monument's identification study and national register evaluation study is completed, the next critical need will be the revision of the present Archeological Overview and Assessment of the monument. The Assessment should emphasize future research designs and data recovery studies.

4. NEED FOR CONSERVATION TREATMENT OF MUSEUM OBJECTS

Over the last 40 years the Museum Technicians or Park Paleontologist, prepared (conservation treatment) all the fossil specimens that had been excavated. Within the last 10 years the monument's collection of historic documents and natural history collections, in addition to fossils, has increased dramatically.

The long range need will be for treatment of the mammal, insect, herbarium, and other collections that will suffered from aging.

a. PROVIDE TREATMENT OF HISTORIC DOCUMENTS AND RARE LIBRARY AND PALEONTOLOGY BOOKS

Historic documents pertaining to early fossil excavation activities (1909 - 1924), the expansion of the monument in 1938, and the Echo Park dam controversy in the early 1950's are stored at the monument. Rare paleontology books and papers as well as rare history books and magazines are stored in the park and paleontology library. All of these rare and important documents, books, and periodicals are printed on acidic paper. Acidic paper gradually deteriorates no matter how well it is protected and can crumble to "dust" in a matter of 50 years. All of the documents need treatment (deacidification) to halt their deterioration before proper storage and duplication can be initiated to preserve this invaluable information base.

b. MICROFICHE HISTORIC DOCUMENTS

This project is related to 1400-C-018, treatment of historic documents and rare books. Treatment of these documents will halt

their deterioration by the acid in the paper. However, no matter how well we protect these documents from environmental impacts, they will eventually deteriorate. In addition, researchers will prowl through these documents and take their toll on them over time. The best solution is to duplicate all the documents in a medium that allows long term storage and easy access by researchers. Microfiche duplication of all these documents would fill the bill.

c. UPGRADE MUSEUM COLLECTION PREPARATION LABORATORY

The paleontology lab serves as the site for preparation and conservation work on fossil specimens, a major resource management activity at DINO. These specimens are often unique, of high scientific value, and range in size from microscopic teeth to 600 pound dinosaur bones. Presently, the lab is also serving as the storage area for most of the paleontological part of the museum collections which are stored in museum cabinets, open rack shelving, and tables. This cramps and severely limits the space available for preparation and conservation work. The lack of a rolling block and tackle makes moving 600-1,000 pound blocks nearly impossible and certainly hazardous. The lack of digital scales and hot plates makes molding and casting of minute fossils difficult and time consuming. The lack of digital hot plates also makes heavy liquid separations of fossil bearing matrix extremely difficult. The lack of an adequate lab compressor makes the use of more than one air abrasive tool impossible. These equipment shortfalls affect conservation activities and the rate at which specimens can be prepared and become available for study. In the case of some preparation and conservation activities, the lack of a proper exhaust system presents a threat to employee's health and safety (noxious chemicals, adhesives and casting resins producing harmful vapors, suspended dust and silica particulate matter, radon emissions from many specimens, radioactivity from some specimens). The upgrade of the preparation laboratory is dependent upon the completion of a new storage building and moving the collections presently stored in the lab to the new building.

The critical need for conservation treatment is the deacidification of historic documents that relate to the park's history and early fossil excavation activities. Without treatment, these documents may soon be lost before they can be microfiched. A 10-238 requesting funds for conservation treatment of museum records has been submitted.

5. INADEQUATE STORAGE AND ENVIRONMENTAL CONTROLS FOR MUSEUM OBJECTS

The 1985 General Management Plan recommended that a new curatorial storage building be constructed. As a result a 10-238 was submitted for the construction of a curatorial storage building. In 1990 the 10-238 was revised. Currently museum objects are stored in the paleontology preparation laboratory, the Monument Headquarters office basement, and tin sheds. None of these storage areas have adequate environmental controls, although the HQ basement environment normally is constant and meets guidelines. Many large fossil specimens stored at the Quarry are on open rack shelves or benches and are exposed to dust and touching. Both storage areas have intrusion and fire alarms, but only the Dinosaur Quarry has a fire suppression system. The HQ storage area is dedicated museum object storage space except for the radio base station equipment housed there. The Quarry storage space is open to employee traffic and is also used as office and preparation space by the Museum Technicians.

a. CONSTRUCT MUSEUM STORAGE BUILDING

The present inadequate storage facilities must be replaced with a new storage building that meets standards and is large enough that the collections can grow into the space. The preparation laboratory lacks proper lighting, sinks, and work stations. When the fossil specimens are removed to a new collections storage building the laboratory should be remodeled and its equipment upgraded.

b. MEDIA SAFE

The monument's historical documents are stored in locked fire proof file cabinets. However, a media safe is needed for the historical photographs, audio tapes, and video tapes that constitute the visual record of the monument's history.

The highest critical need for the curatorial program is the construction of a new collections storage building. A Collection Storage Plan has been prepared to guide the design of the museum storage building. Presently, environmental controls of the storage environment do not exist, collections security is poor to nonexistent, collection storage space is becoming scarce. This causes the paleontology staff to reconsider salvage excavations of large threatened fossils because there is not enough adequate storage space. Fossils specimens may be lost to erosion or theft because of limited storage space! Of equal importance is the establishment of a permanent Museum Aid to maintain the curatorial program.

6. CONTROL OF ENVIRONMENTAL IMPACTS ON CULTURAL SITES

Erosion and livestock grazing are the major known natural impacts affecting cultural resources. However, there are other impacts

such as ultra violet light "bleaching" pictograph pigments, brush abrading rock art, rodents burrowing into buried cultural layers, windblown sand, lichen, bird droppings, and visitor use. The impacts of livestock grazing were partially controlled in 1986 with the elimination of grazing by public law on 52,330 monument acres. However, grazing continues on about 80,000 acres of the monument and will be with us for the foreseeable future. The Park Archeologist has mitigated the effects of erosion on two burial sites by excavating the human remains. However, there are no current plans to control erosion on archeological and historical sites. The reason for this is the lack of knowledge about the location and significance of sites and the lack of a monitoring program to identify sites with significant impacts.

The need for control of erosion and grazing is less critical than the need for an archeological sites identification study and monitoring program. However, there are critical needs which can be handled by the present staff. This includes cutting brush abrading rock art, fencing alcoves heavily impacted by livestock, completing rock art documentation.

C. MONITORING

1. CONTROL OF VISITOR IMPACTS (EXCESSIVE FOOT TRAFFIC, WALL CLIMBING, TOUCHING, RECREATIONAL IMPACTS, ETC.)

a. INTERPRET CULTURAL SITES

We know that looting, recreational collecting (hunting arrowheads), and vandalizing rock art are taking its toll. Recently interpretation has begun installing interpretive signs at heavily visited archeological sites. These signs educate the public to site fragility, respect for cultural remains, and low impact visitation behavior. Recently some attempts have been made to block social trails at heavily visited sites and reroute paths to reduce impacts. The exhibits at the Headquarters visitor center are scheduled for replacement. The concept design for new exhibits calls for a display of archeological artifacts and information on prehistoric Native Americans and an exhibit that deals with some of the historic sites in the monument. The draft Interpretive Prospectus calls for publications that describe the prehistoric and historic events of the monument.

b. INCREASE PROFESSIONAL STAFF

Signs and wayside exhibits are limited in their approach. Visitors cannot readily ask questions and cannot explore with a ranger insights into cultural resources. Interpreters leading talks and

guided walks at cultural sites can deal with the protection of cultural resources in depth and can model for the visitor proper behavior at cultural sites. The presence of a uniformed interpreter in areas with a high density of cultural sites are as effective a deterrence to looting and vandalism as are law enforcement personnel. The unfortunate result of recent budget shortfalls has been the elimination of walks and talks at cultural sites.

2. INADEQUATE CULTURAL RESOURCES MONITORING PROGRAMS

a. MONITOR CULTURAL SITES

In the past "monitoring" has been informal - a ranger observes a change at a site and reports it. Written records of these "reports" may or may not have been made. Follow-up has been almost non-existent. Some follow-up has been possible in recent years with ARPA funding.

Monitoring visitors and sites will be the only way the monument can determine the extent of visits at cultural sites, what visitors are doing at sites, determine rates of deterioration, and determine what environmental factors are impacting sites. Our ignorance of the condition of sites, their rate of deterioration, and the frequency of their exposure to the public prevents sound management planning in several ways. First, it makes informed planning for protection patrols impossible. Second, it makes the identification of sites that need an interpreter, or deciding which sites need interpretive signs, guesswork. Third, it prevents management from planning and funding mitigation work that will halt or reduce natural impacts.

b. CRACK MONITORING SYSTEM

When the overburden of mudstone was removed from the Quarry cliff face to expose the bone bearing sandstone layer, isostatic rebound began. The effect of isostatic rebound is to enlarge the naturally occurring cracks that run through the rock and fossil specimens. As the cracks enlarge, they must be repaired and stabilized. A crack monitoring system needs to be set up at the cliff face to record the rate of crack growth. A 10-238 has been submitted for a crack monitoring system.

c. MONITOR MUSEUM COLLECTIONS

The present staff can make a better effort to monitor the museum collections. Certainly if the monument ever obtains a permanent Museum Aid, monitoring the collections will be a task for this position. At present, regular, periodic monitoring of the collections for infestation and degradation is not done. Inspec-

tions are infrequent and less than thorough and may not detect infestations and degradation at an early, treatable stage. There is no program for cleaning collection areas, checking seals of museum cabinets, etc. Currently there is no monitoring of temperature and humidity in storage areas. Baseline data on the fluctuations of such environmental parameters is not being gathered and such threats remain unrecognized and unaddressed.

As was indicated earlier, monitoring is important, but not as critical as an archeological sites inventory study that would identify all the sites in the monument. With this information a comprehensive monitoring strategy could be developed.

D. PROTECTION

1. INADEQUATE SECURITY (LOOTING, VANDALISM, GRAFFITI, ARSON, AND BURGLARY SYSTEMS)

a. INCREASE ARPA PATROLS

There presently are not enough law enforcement positions to adequately patrol areas of the monument that contain high concentrations of cultural sites. These areas include Jones Hole, Island Park/Rainbow Park, Pool Creek/Echo Park/Yampa Bench, and the river corridor of the Yampa River. All these areas are patrolled on an infrequent basis, but do not receive daily patrols which are recommended to protect these cultural sites.

b. INCREASE PROFESSIONAL STAFF

Vandalism, looting, and collecting at cultural sites has occurred from the time the area was first settled. Many alcoves show evidence of looting activities. Most petroglyphs have been scratched with graffiti, shot, and touched. On many sites one can find collector piles of lithics indicating arrowhead and tool collecting. Fortunately the level of human impacts is lower than in parks to the south. This would seem to bode well for patrol efforts to prevent and detect violations of protective laws. However, budget inroads have gradually reduced the protection and interpretation staffs in the monument.

Since 1990, Region provided funds to hire a temporary ARPA ranger to monitor and patrol cultural sites. Patrols by the ARPA ranger focused on 25 sites and included site monitoring (comparing present observations with past records), photographic updates of records, visitor contacts, discrete observation of visitor behavior, delineating trails, collecting litter, and investigation of possible ARPA violations. Despite these initial efforts by the

ARPA ranger the monument is still missing information on all the easily accessible sites about the numbers of visitors that are coming to our cultural sites and what they are doing to the sites when they are there. Without this information our assumptions about where to put signs, locate trails, and concentrate law enforcement patrols are inaccurate.

With the exception of the one seasonal ARPA ranger, other required duties and concerns prevent law enforcement patrols for the express purpose of protecting cultural resources.

The inability to conduct adequate monitoring and law enforcement patrols has contributed to the lack of detection and apprehension of looters, recreational collectors, defacement of rock art, and two years ago, the loss of three National Register structures to fire.

Without a doubt there is an inadequate number of law enforcement rangers to properly patrol the monument and monitor cultural sites. It is estimated that it would take an additional 1.5 MY to adequately patrol and monitor cultural sites. Presently there are three rangers who have attended ARPA violation investigation training. As these people transfer, other rangers will need to attend this training.

Interpretation in the form of a ranger at a cultural site, or interpretive signs, can instruct the public about how to visit and protect cultural sites. The presence of an interpreter at a site is as much a deterrent to vandalism and looting as the presence of a law enforcement patrol ranger.

c. UPGRADE FIRE/INTRUSION ALARM SYSTEM AT HEADQUARTERS AND DINOSAUR QUARRY

Intrusion and fire alarms were installed in the Dinosaur Quarry and the Headquarters office building. The same system has a fire suppression capability at the Quarry, but not Headquarters. These two systems protect the museum collections stored at both these buildings. The system has been repaired numerous times. With the exception of the Dinosaur Quarry, there are no historic structures or archeological sites with intrusion alarms.

2. NEED FOR EMERGENCY SITE AND STRUCTURE STABILIZATION

During the FY-1988 a Section 106 archeological reconnaissance along the Echo Park Road was completed. One of the functions of the survey was to made recommendations for sites which continue to be impacted by cyclic road maintenance, road traffic, and surface runoff erosion. From the total sites located, 18 needed further

work, 7 were recommended for testing, and 5 were recommended for mitigation excavation and stabilization of site cutbank adjacent to the road grade. After completion of the final survey report and submission of the above recommendations further work has not occurred because of the lack of funds and personnel.

The three sites recommended for testing and the five sites recommended for salvage excavation and cut bank stabilization continue to be adversely impacted by erosion, road traffic, and cyclic road maintenance. Archeoloigical materials are being lost due to these impacts.

This is a critical need.

3. PROFESSIONAL STAFFING NEEDS

Table 1 indicates that funding is currently present for cultural resource management. However, funding for the archeologist position will be eliminated at the end of fiscal year 1991. Beginning fiscal year 1992, the cultural resource program will again be unfunded and managed by a non-professional who has the collateral duty as Cultural Resource Management Specialist.

A GS-9/11 Archeologist is needed to handle 106 clearance work, provide the Cultural Resource Management Specialist with professional consultation, and to oversee contract archeological work.

A GS-3/4 Clerk Typist is needed to assist the archeologist and Cultural Resource Management Specialist with the completion of site forms, catalog forms, plans, and reports.

A GS-5 Museum Technician is needed to handle the ever increasing curatorial workload.

Two GS-5 seasonal Park Rangers are needed to monitor archeological and historical sites and visitor activities at those sites.

Four GS-5 seasonal Park Rangers are needed to provide law enforcement patrols in highly visited and sensitive cultural districts (Jones Hole, Island Park, Echo Park, and the Yampa River corridor).

One additional man year of WG-9 maintenance position(s) are needed to do preservation maintenance on the National Register historic structures.

Four GS-5 seasonal Park Ranger interpreters are needed to provide guided interpretive walks and talks about the monument's most visited cultural sites (Jones Hole, McKee Springs, Cub Creek, Sand Canyon/Echo Park).

E. SUMMARY OF CRITICAL NEEDS

The project statements for cultural resources mentioned in the overview section are listed in this summary in priority order. The priority was set based upon the following hierarchy of five criteria:

1. Management's most immediate need is to know what to do about critical resource needs. This is a planning criteria that must be met before certain project statements can be implemented.

2. At the same time, management must try and mitigate known and immediate impacts that are causing present on-going loss of resources (these are resources DINO will loose in the next several years).

3. When the first two management imperatives are met, management can begin to determine the extent of the resources (baseline data). This includes the location, type, condition, threats, and finally significance of all cultural resources.

4. When management has the information needed on resources, it should take action to mitigate impacts, place people in the field to interpret and protect the resources, monitor the resources and mitigate new threats that come up.

5. With the luxury of baseline information and a resource protection program in place, management should begin further research studies of the resources for scientific interest and to improve interpretation.

One caveat. If funding becomes available for priority project #32 and priority project #1 is unfunded, this priority listing should not be interpreted to mean exclusion of #32 until #'s 1-31 are completed. This listing indicates the relative degree of need from one project statement to another. The hierarchy was used to formulate this list to reduce subjective evaluation (favoritism) or relative importance.

CRITICAL PROJECT STATEMENTS THAT ADDRESS IMMEDIATE RESOURCE NEEDS OR NEEDS WHERE THE RESOURCE IS IN THE IMMEDIATE JEOPARDY OF BEING LOST OR SEVERELY DAMAGED

1. Upgrade museum collection preparation laboratory.
2. Stabilization Assessment and Preservation Guide for National Register structures.
3. Rock art documentation and establishment of a monitoring program.
4. Control environmental impacts on cultural sites.
5. Section 106 clearance for all developed areas and write a PMOA.
6. Stabilize, test, and salvage archeological sites - Echo Park Road.
7. Complete stabilization work on National Register structures.

CRITICAL PROJECT STATEMENTS THAT MEET NEEDS THAT ARE NOT IMMEDIATE

8. Construct museum storage building.
9. Provide treatment of historic documents and rare library and paleontology books.
10. Amplification of oral histories.
11. Cyclic preservation maintenance for National Register structures.
12. Archeological Inventory Study.
13. Monitor cultural sites.
14. Archeological Evaluation Study.
15. Dendrochronology Study.
16. Quaternary Soils Study.
17. Provide documentation of Quarry excavations.
18. Cultural Landscape Report.

LESS CRITICAL PROJECT NEEDS

19. Microfiche archeological field notes and reports held by the University of Colorado.
20. Microfiche historical documents.
21. Media safe.
22. Increase professional staff.
23. Monitor museum collections.
24. Crack monitoring system.
25. Interpret cultural sites.
26. Increase ARPA patrols.
27. Revise Archeological Overview and Archeological Assessment.
28. Ethnohistory.
29. Update Administrative History.

Table 1
NPS RESOURCE PERSONNEL
(CURRENT YEAR ONLY)

TYPE OF EMPLOYEE	FTE OF RESOURCES WORK		
	Natural	Cultural	Total
Research Scientists			0.0
Resources Specialist			1.0
025 Park Rangers - Resources Management			0.1
025 Park Rangers - Resources Protection			0.3
025 Park Rangers - Resources Interp			0.0
Total of all Resources Personnel			1.4
Total Park FTE — Percentage of Park FTE Devoted To Resources			2.6%