Biological Inventory of National Park Areas on the Southern Colorado Plateau

Aztec Ruins National Monument
Bandelier National Monument
Canyon De Chelly National Monument
Chaco Culture National Historic Park
El Malpais National Monument
El Morro National Monument
Glen Canyon National Recreation Area
Grand Canyon National Park
Hubbell Trading Post National Historic Site
Mesa Verde National Park
Navajo National Monument
Petrified Forest National Park
Petroglyph National Monument
Rainbow Bridge National Monument
Salinas Pueblo Missions National Monument
Sunset Crater Volcano National Monument
Walnut Canyon National Monument
Wupatki National Monument
Yucca House National Monument

Colorado Plateau Cooperative Ecosystem Studies Unit

- and -

USGS / Colorado Plateau Field Station

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Biological Inventory of National Park Areas on the Southern Colorado Plateau

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1. Introduction

1.1 National Park Service Inventory Program – Background

Part of the purpose and legislative mandate of the U. S. National Park Service (NPS) is to protect and preserve the plants, animals, and biological communities of the federal lands that it manages. This is reflected in the founding legislation of the agency, which describes the mission of the Park Service as "…to conserve the scenery and the natural and historic objects and the wildlife therein…" (National Park Service Organic Act 1916). Park Service policy and guidance have long recognized the important need for basic inventory data of natural resources. Part of the Park Service's management policies states: "The National Park Service will assemble baseline inventory data describing the natural resources under its stewardship and will monitor those resources at regular intervals to detect or predict changes" (NPS Management Policies 4:4 1988). However, practice has not always kept up with policy, and many Park Service areas remain seriously deficient in even basic inventory data (e.g., Stohlgren and Quinn 1992).

The Park Service renewed its focus on natural resource inventory and monitoring in 1992 with the creation of a Park Service-wide Inventory and Monitoring Program. In fiscal year 2000, the Park Service received a substantial budget increase for inventory and monitoring studies, and a nationwide program to inventory vertebrates and vascular plants within the national parks was begun in earnest. As part of this new inventory effort led by the Inventory and Monitoring office, a total of 265 National Park units (parks, monuments, recreation areas, historic sites, etc.) were identified as having significant natural resources, and these were divided into 32 groups or "networks" based on geographical proximity and similar habitat types. The many NPS areas on the Colorado Plateau of Utah, northern Arizona, northwestern New Mexico, and western Colorado were divided into a northern and a southern network. This proposal provides an inventory plan for the 19 park units in the southern Colorado Plateau (SCP) network (see Table 1 for a list of member parks) (Fig. 1).

Table 1. List of NPS management areas in the Southern Colorado Plateau Network.

ACRONYM	TITLE
AZRU	Aztec Ruins National Monument
BAND	Bandelier National Monument
CACH	Canyon De Chelly National Monument
CHCU	Chaco Culture National Historic Park
ELMA	El Malpais National Monument
ELMO	El Morro National Monument
GLCA	Glen Canyon National Recreation Area
GRCA	Grand Canyon National Park
HUTR	Hubbell Trading Post National Historic Site
MEVE	Mesa Verde National Park
NAVA	Navajo National Monument
PEFO	Petrified Forest National Park
PETR	Petroglyph National Monument
RABR	Rainbow Bridge National Monument
SAPU	Salinas Pueblo Missions National Monument
SUCR	Sunset Crater Volcano National Monument
WACA	Walnut Canyon National Monument
WUPA	Wupatki National Monument
YUHO	Yucca House National Monument

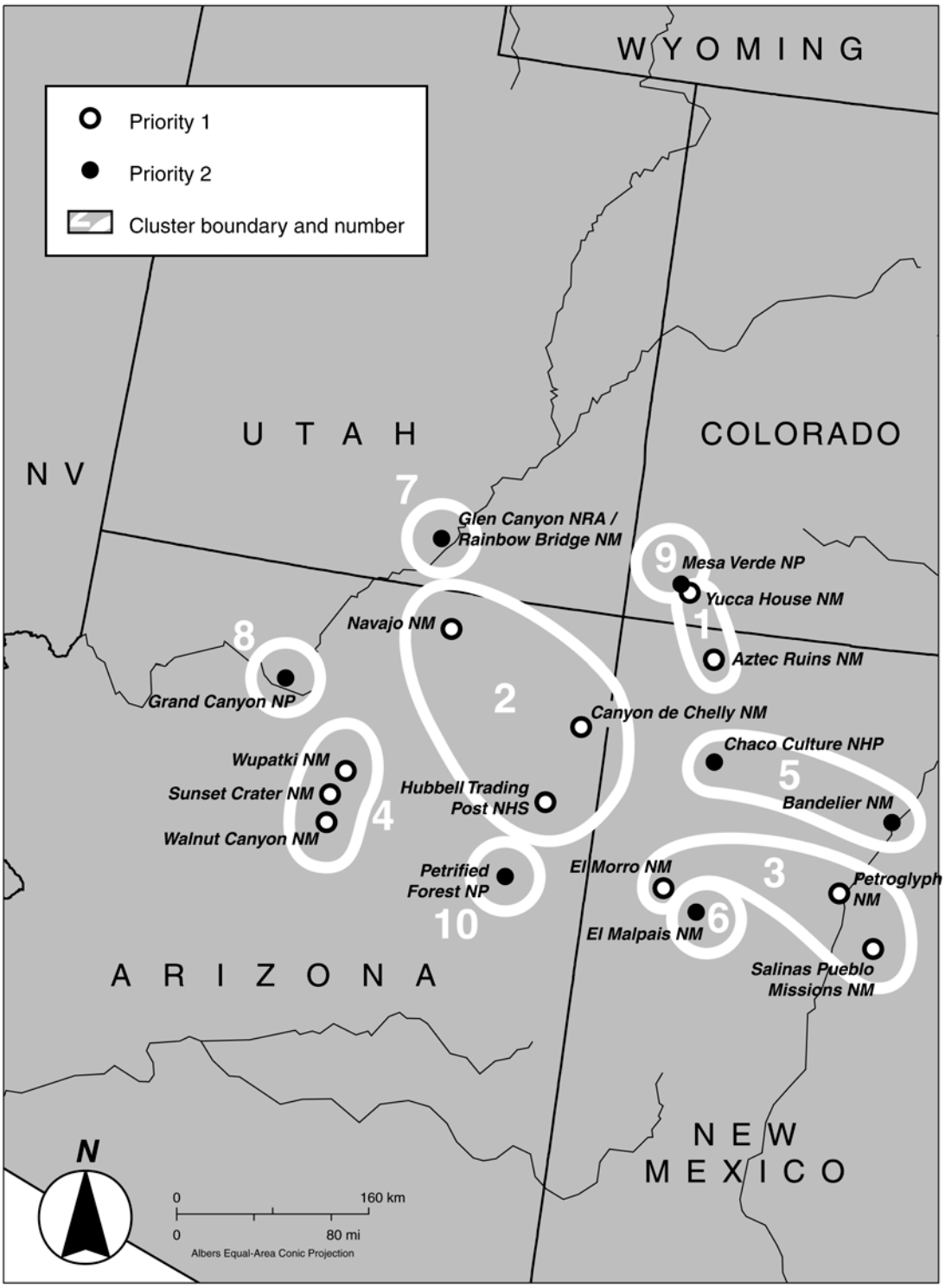

Figure 1. Map showing southern Colorado Plateau Network park units. Clusters are outlined in white and identified by number (see section 3, **Priorities for additional work**).

This proposal is the product of collaboration by representatives of the 19 parks in the southern Colorado Plateau network, the newly-established Colorado Plateau Cooperative Ecosystem Studies Unit (CPCESU) at Northern Arizona University, the U. S. Geological Survey's Biological Resources Division, and regional experts from a number of universities and state and federal agencies. The goal and efforts of all of these participants have been to develop a plan for biological inventories that are efficient, thorough, scientifically sound, statistically valid, and which meet the criteria established in the NPS "Guidelines for Biological Inventories" and the NPS-75 Inventory & Monitoring Guidelines.

This proposal describes the physical setting and range of habitats in the southern Colorado Plateau park units, establishes inventory priorities for the park units within the network, describes management issues in relation to biological inventory and monitoring needs**,** and details how vertebrates and vascular plants will be inventoried and documented for the Southern Colorado Plateau Network park units. The proposal provides a timeline for completion of inventory studies for the network, and describes the products that will result from the work. It also provides individual project statements, as studies of a particular taxonomic group (e.g., plants, birds or mammals) within a single park or a cluster of park units in close proximity, and a detailed budget for each individual project statement proposed as part of the network effort. Long-term data management, integration, and application are important parts of the inventory program, and are outlined and discussed in detail. Because there is a fixed level of funding for the Southern Colorado Plateau Network through the national inventory program, individual project statements and associated data management needs are prioritized, with the most important projects (highest priority) funded through available inventory funds. Project statements that fall below the level of funding available are included in appendices, and efforts will be made to fund them through other sources.

Long-term biological inventory goals for each park are to provide: (1) complete bibliographies of studies pertinent to biological inventory of network parks; (2) detailed summaries of biological survey and natural history specimen data for the network parks; (3) species lists for each taxonomic group in relational database and hard copy format; (4) relative abundance estimates for selected species of concern in each vertebrate and vascular plant taxonomic group; (5) spatially located data for species of interest or concern; (6) spatial data on sampling site locations for GIS and a GIS data browser; (7) pertinent herbarium and museum vouchers databases; and, (8) recommendations for long-term monitoring within the network.

1.2 Organization of this proposal

This proposal is organized into ten sections, as follows:

1. This introduction and background to the southern Colorado Plateau park units, and natural resource inventory needs;
2. A review and summary of existing information related to biological inventories, and inventory needs, in the 19 park units in the SCP;
3. Building on the existing inventory data for the SCP parks, a discussion and explicit listing of inventory priorities for the 19 park units;
4. Detailed design and methods for proposed inventories for the SCP units, including overall sampling design, and field methods for each of the vascular plant and vertebrate groups included in the proposed inventories (this section provides a general integrated design and methodology for all of the park units included; detailed methods and schedule of work for each park unit or group of parks is included as section 10, Individual Project Statements);

5. Outline and discussion of how data from the inventory work will be collected, checked for quality and completeness, analyzed, managed over the long term, and made available for use by the SCP park units. This section also includes discussion of the need for, and collection and handling of, voucher specimens for the different taxonomic groups;
6. Individual project statements, providing detailed objectives, methods, and schedules of work, arranged by taxonomic group and by the park unit or units (most of the project statements are for inventories of small groups of parks in a local area).
7. Budget for the proposed inventory studies, arranged by taxonomic group and park units that will be included in the inventory;
8. Schedule of work for the inventories, including background review of data and other preparation, fieldwork (by taxonomic group and park unit), data analysis and reporting, and associated budgets;
9. Products of the inventory studies, including written reports, presentations to the park units involved, tabular and GIS data products, and annotated lists and bibliography;
10. Coordination and integration of work across the 19 SCP park units, assurance of data quality, applicability, and comparability among the different areas surveyed. This section also includes discussion of logistical and administrative support from the member parks, the Colorado Plateau CESU, participating universities, and the USGS.

A Literature Cited section and several appendices providing detailed background data, more detailed discussions of sampling design, and other supporting information, are included at the end of the proposal.

1.3 Project Oversight and Partnerships

In meeting the objectives of the southern Colorado Plateau inventory project, the project coordinators will ensure that the inventory studies are carried out with a high level of scientific rigor, that products produced are of value towards management of the southern Colorado Plateau park units, and that the work provides a strong foundation for an effective long-term monitoring program. A close partnership will be maintained with the Northern Colorado Plateau (NCP) inventory program to ensure consistency in form and quality of data and to seek efficiencies in budgets and staffing.

Implementation of the inventory program will be guided by a 6-person steering committee made up of park resource managers and superintendents. A full time coordinator has been selected and is stationed at the Colorado Plateau Cooperative Ecosystem Studies Unit (CPCESU) on the campus of Northern Arizona University. As Dr. Anne Cully is a plant ecologist, she will conduct or directly coordinate many of the vascular plant surveys. Data management and related GIS work will be carried out in cooperation with the USGS Colorado Plateau Field Station (CPFS). NPS will hire and station a term GIS/Data Management Specialist in the GIS Laboratory of the CPFS. CPFS will provide assistance from their GIS Specialist, use of equipment, and access to reduced license rates for software. Students will be readily available for data entry and technical duties. The NPS CPCESU leader will serve as liaison between the NCP and SCP networks. The CPCESU will serve as the home of the SCP inventory program. The majority of the inventory work will be conducted through modifications of the CPCESU cooperative agreement with Northern Arizona University and 9 other partners. Significant involvement of the USGS Colorado Plateau Field Station is also anticipated. Interested and qualified investigators will be sought through requests for interest and qualifications. Subject matter experts who provided information on the background, methods, and sampling plans for this proposal will continue their relationship with the project. They will provide guidance to additional investigators conducting the work outlined here, to help ensure that the data collected is compatible and appropriate to project goals. We anticipate, in most cases, highly qualified investigators will be found within the CPCESU partners and/or the Colorado Plateau Field Station. If not, the search will be broadened.

Other significant partners in the SCP program will be the Navajo Nation Natural Heritage Program which will conduct inventories for Canyon de Chelly, Hubbell Trading Post, and Navajo National Monument, which are located within the boundaries of the Navajo Nation. The CPCESU will also facilitate and support internships for Native American students from Haskell Indian Nations University and Diné College, and other partner institutions, to assist in the inventory project.

As part of project oversight and coordination, the CPCESU will host an annual meeting of project partners and investigators of both the NCP and the SCP inventory projects, to report on progress. This will be done in association with the Colorado Plateau Biennial Research Conference, which will be held next in fall 2001. In addition, the CPCESU will provide assistance in finding funding for projects not covered by this project (this could include use of NPS CPCESU project funds). The CPCESU web site will also serve biological inventory data resulting from this work, with the greater Colorado Plateau community and with the general public.

1.4 Southern Colorado Plateau Network– Physical Setting

The NPS units included in the Southern Colorado Plateau Network are in Arizona, Colorado, New Mexico, and Utah. They range in size from more than a million acres (GRCA and GLCA) to 34 acres (YUHO), and encompass a diverse array of landforms, elevation ranges, geologic substrates, vegetation types, and wildlife habitats. Most are within the Colorado Plateau region, and are dominated by Colorado Plateau shrubland, grassland, and pinyon-juniper woodland vegetation. However, the peripheral parks and elevation extremes are allied with the Mogollon Highlands, Great Plains, Sonoran Desert, Chihuahuan Desert, Middle Rio Grande Basin, and Southern Rocky Mountain regions.

The Colorado Plateau region lies in the zone of arid-temperate climates in North America. This type of climate is characterized by periods of drought and irregular precipitation, relatively warm to hot growing seasons, and long winters with sustained periods of freezing temperatures. Petersen (1994) provides a good overview of the climate on the Plateau. Winters are dominated by Pacific region storm patterns, while summers are dominated on the southern portions of the Plateau by monsoonal moisture from the Gulf of Mexico. Orographic effects control local climates on the central portions of the Colorado Plateau (Spence 2000). Evapotranspiration rates are extremely high for a temperate region, resulting from hot summers and extremely low precipitation (100-250 mm/yr in most locations).

The vegetation is characterized by low, open woodlands of drought-adapted conifers at higher elevations, and extensive areas of drought-tolerant shrubs and grasses at lower elevations. At the highest elevations, significant communities of Ponderosa Pine, mixed conifer, and subalpine forests occur, especially at Grand Canyon NP and Bandelier NM. Due to freezing temperatures in the winter, large succulents that characterize subtropical and warm-temperate regions are lacking. The arid-humid boundary lies at an extremely high elevation of 2700 m on the central portion of the Colorado Plateau (Spence 2000), although it is somewhat lower (ca. 2500 m) to the southwest on the Kaibab Plateau. Above this elevation small areas of conifer forests, and montane and subalpine meadows, are found. A few small patches of alpine tundra occur on the tops of some of the higher peaks, although none occur in NPS units.

Although the Colorado Plateau has been a distinct geological region for much of the Mesozoic and Cenozoic, the vertebrate biota is in many ways impoverished compared to surrounding areas. This may result both from history, because of the relatively rapid rise of the region combined with increased erosion and cooling temperatures since the Miocene, and from harsh climate. Other than numerous fish species, only one vertebrate species, Stephens woodrat, appears to be endemic to the Colorado Plateau (Hoffmeister 1986). A second species, the Jemez Mountains salamander, occurs in the Jemez Mountains of northern New Mexico.

In contrast to the fauna, the vascular flora of the Colorado Plateau is extremely rich. The region supports one of the highest levels of endemism in the U.S., with about 10% of the 2500-3000 plant species on the Plateau estimated to be endemic. Schultz (1993) points out that 50% of the endemic plants in Utah (ca. 120 species) occur on the Colorado Plateau. Many of these species are either federally listed or otherwise rare. The high diversity of habitats (especially geologic substrates), together with drastic climatic fluctuations during and since the Pleistocene, may have favored explosive speciation in herbaceous taxa in the region.

Serious gaps exist in our understanding of some taxonomic groups on the Colorado Plateau. In particular, relatively little is known about the status and distribution of bats, small mammals, reptiles (especially snakes), amphibians, indigenous annual plants, and exotic plants. Even available data on the better-known large mammals, birds and perennial plants is uneven in quality. Good biological inventory data and reliable species lists are critical to understanding the natural resources in each of the network park units, and will provide useful information for a wide range of resource management issues.

1.5 Study Area Vegetation

Portions of six floristic provinces occur in and adjacent to the study area. These are the Colorado Plateau, Great Basin, southern Rocky Mountains, Sonoran, Chihuahuan, and Madrean provinces (Brown 1994, McLaughlin 1989, 1992). The majority of the parks are on the Colorado Plateau and are characterized by Plateau assemblages. El Morro NM and El Malpais NM have some Chihuahuan influences, while Mesa Verde NP and Bandelier NM have some southern Rocky Mountain elements. Walnut Canyon NM includes elements of the Madrean province. Grand Canyon NP has a large Mojavean (or Sonoran, using McLauglin's classification) element. The flora of Salinas Pueblo Missions NM is primarily Chihuahuan and southern Great Plains. Major studies discussing the flora and vegetation of this region include Reveal (1979), Brown (1982), Axelrod and Raven (1985), Barbour and Billings (1988), McLaughlin (1986, 1989, 1992), Dick-Peddie (1993), and McLaughlin and Bowers (1999).

The Colorado Plateau is a center of plant speciation and endemism. Although no attempt has been made to determine the size of the flora, there are an estimated 2500-3000 species. About 10% of this flora is endemic (Schultz 1993), consisting mostly of herbaceous dicots in the genera *Astragalus*, *Cryptantha*, *Erigeron*, *Eriogonum*, *Gilia*, *Phacelia*, and *Penstemon*. Many of these species occur in or near parks on the Plateau.

Studies elsewhere have revealed that parks can harbor much of the biodiversity of a region. For example, Falkner and Stohlgren (1997) found that 44 parks in the Rocky Mountain region supported much of the biodiversity of the region, and that the smaller parks contributed a disproportionate amount to this biodiversity. To date, no analysis has been done on the Colorado Plateau parks to determine how many of the vegetation types of the Colorado Plateau province are protected within National Park units. We (J. Spence) developed an EXCEL database with preliminary lists of vegetation types for the 19 network park units (Appendix A). Vegetation type nomenclature is based on the Spence-Romme-Floyd-Hanna-Rowlands (SRFR; Spence 1997) classification which is named by the dominant species or species group; for example, ponderosa pine forest or pinyon-juniper woodland). Currently, 74 alliances are recognized among the park units in the SCP network, organized into forest and woodland, savanna, shrubland, mat shrubland, grassland, marshland, forbland, barren, and unclassified types. This list is not likely to be complete for all 19 park units. Some of the alliances recognized may not actually be represented by on-the-ground vegetation.

The most widespread alliances are pinyon-juniper woodlands; big sagebrush, blackbrush, four-wing saltbush, and sand-shrub shrublands; Fremont Cottonwood, tamarisk, and coyote willow riparian forests and shrublands; and galleta and blue grama grasslands. The majority of park units in the southern

Colorado Plateau network support these alliances or vegetation types. There are two principal exceptions to this: the Sonoran vegetation in Grand Canyon NP, and the high elevation conifer and aspen forests of Grand Canyon NP and Bandelier NM. Scattered throughout the SCP network there are areas of local unusual or in some cases unique vegetation, including hanging gardens, spring-supported deciduous woodlands, and mat shrub and forb-dominated vegetation on badlands of clay and gypsum.

Sources of major floristic information for the Colorado Plateau include, by state; Colorado: Weber (1986), Spackman et al. (1997); Utah: Welsh et al. (1993), Albee et al. (1988), Cronquist et al. (1972-1998), Utah Rare Plant Guide (in revision); Arizona: Kearney and Peebles (1960), Arizona Flora (in prep.), McDougall (1973), Rutman (1990); New Mexico: Martin and Hutchins (1980), Spellenberg (1993), Sivinski and Lightfoot (1995). Also, there are numerous published papers, unpublished checklists, and theses for many areas on the Colorado Plateau, as well as for specific parks. These publications and reports are discussed as part of the park-specific project needs and priorities.

1.6 Background for Southern Colorado Plateau NPS units

Aztec Ruins National Monument (AZRU)– Aztec Ruins NM preserves an archeological site with a reconstructed example of a great kiva, a type of ceremonial structure found in the Four Corners area at sites of the Chaco period (900 A.D. – 1150 A.D.) AZRU is located in the Animas River valley in northwestern New Mexico. The site includes riparian, lowland , and upland areas. The natural resources of this site, including water, croplands, and riparian vegetation, were important to the prehistoric inhabitants. Today, these same resources are an important aspect of the monument, and provide a context for understanding the development of the Chacoan culture. Inventory of plant and animal species is necessary to establish a baseline of abundance and distribution in order to detect future changes due to development within the park. The presence of threatened, endangered, and other sensitive plant and animal species should be documented so that protection can be assured during development (e.g., new buildings, trail work, fences, oil and gas leases). There is also a need to identify, map, and eradicate noxious weeds to prevent further encroachment and to meet federal mandates. Baseline data are also needed in order to plan the revegetation of areas disturbed by roads, grazing, and agricultural use.

Bandelier National Monument (BAND)– Bandelier National Monument is located in the Jemez Mountains of New Mexico. The Presidential proclamation that created Bandelier in 1916 (No. 1322; stat. 1764:1916) stated that "... certain prehistoric aboriginal ruins… are of unusual ethnologic, scientific, and educational interest, and it appears that the public interests would be promoted by reserving these relics of a vanished people, with as much land as may be necessary for the proper protection thereof...." The significance of Bandelier lies in its superb combination of cultural, natural, and wilderness values. To recognize the wilderness values, President Ford signed legislation in October 1976, creating a 9,423 hectares (23,267 acres) Bandelier Wilderness (Public Law 94-567). Ninety percent of the park is managed as wilderness, and more than half of its trails (Frijoles Cañon and Bandelier Backcountry) are part of the National Trail System. Bandelier's ecosystems and their biogeophysical elements are highly altered, poorly understood, and possibly unstable. Loss of naturally functioning ecosystems as a result of historic grazing and fire suppression are causing accelerated loss of soils and cultural resource values and material remains, catastrophic fires, and unnatural changes in plant and animal abundance and distribution. Adjacent land management missions are largely incompatible with NPS mandates and goals. For example, radioactive contaminants generated by the Los Alamos National Laboratory are entering the food chain, and resource extraction activities on adjacent lands are destabilizing lower watershed (park) soils and associated aquatic and terrestrial ecosystems. At Bandelier, information on natural resources is inadequate to make informed decisions. External threats to the park have been accelerating and we need data to develop sound management plans and to justify our proposed actions. Initial inventory studies will establish current conditions; future monitoring will allow the detection of changes in species composition of communities and habitats.

Canyon de Chelly National Monument (CACH)– Canyon de Chelly is located in northeastern Arizona and protects ruins of Indian villages built between AD 350 and 1300. The monument includes artifacts and remains spanning southwestern Indian history from the earliest basketmakers and their successors to the Navajo Indians who live and farm here. Authorized on April 1, 1931, and including a boundary change in March 1,1933, the present monument now comprises a total of 83,840 acres of nonfederal lands. Cottonwoods and exotic species such as tamarisk and Russian olive both occur along the wash in the upper Sonoran life zone. At lower elevations, juniper-pinyon woodland and Colorado Plateau desert shrub communities exist along the rim. A transition zone of ponderosa pine, Douglas-fir, aspen and Gambel oak is located at higher elevations on the rim and in the Chuska Mountains. Perennial streams occur in the upper third of the canyons and are intermittent in their lower reaches. Subsurface water is available all year.

Chaco Culture National Historic Park (CHCU)- Chaco Culture National Historical Park is located in northwestern New Mexico, near the geographic center of the San Juan Basin Region of New Mexico and adjacent Four-Corners states. The park and a system of Chaco Culture Archaeological Protection Sites (Chaco Protection Sites) were established for the purposes of recognizing and preserving the unique archaeological resources found within Chaco Canyon, the San Juan Basin, and surrounding area. In addition, the park was established to advance our knowledge of the prehistoric Chacoan culture, and to offer opportunities to interpret the archaeological resources and research results to the public. The park is listed in the National Register of Historic Places, and was also designated an UNESCO World Heritage Site in 1987. Although established primarily for its archaeological resources, the park encompasses an a large natural area and is one of only two protected areas in the San Juan Basin Region. The role of the park in conserving regional biodiversity will become more important as park vegetation continues to recover from earlier grazing activities and as land use pressure mounts on the surrounding region. The San Juan Basin is known geologically for its rich coal, oil, natural gas, and uranium resources. Resource managers remain concerned about coal strip-mining leases issued on Federal and tribal lands surrounding the park during the 1980's. These activities would have unknown impacts to the park's fauna unless valid baseline surveys are completed and a reliable monitoring program is developed.

Land within the original national monument was fenced between 1935 and 1948. Today, the park likely represents the largest ungrazed grassland resource in northwestern New Mexico, offering unique opportunities to study the vegetation/habitat recovery of formerly grazed lands, and the composition of bird communities in the absence of domestic livestock grazing pressure. Non-native tamarisk (*Tamarix* spp.) has become a dominant species in riparian areas throughout the Southwestern United States and is common throughout Chaco Wash. Cheatgrass (*Bromus tectorum*) has invaded several thousand hectares within the park. Brown-headed Cowbirds have been documented at the park, including observations of nest parasitism in riparian habitat (Cully 1985b). The House Sparrow (*Passer domesticus*) and Starling (*Sturnus vulgaris*) have become naturalized near human population centers throughout the United States. The former species has not been documented at the park, while the latter is rarely sighted. Should either species become established, resource managers would need baseline inventory information to understand the impacts. Wildfire is generally not believed to have played an important role in maintaining Colorado Plateau Grassland ecosystems. However, the park is in proximity to other biomes in which fire is important, including Great Plains Grassland, Pinyon-Juniper Woodland, and Chihuahuan Desert grassland biomes. As the vegetation recovers from prior grazing disturbance, and as non-native grasses contribute additional combustible material, fuel loads and the potential for grassfires are increasing. The effects of an accidental, wild, or prescribed fire on wildlife habitats and communities would be better understood with a reliable baseline inventory of key habitats within the park. Past research at Chaco Canyon included studies of plant remains from archeological sites and early Holocene packrat middens. The establishment of baseline information on modern plant communities will allow meaningful comparisons of past and present vegetation and assessment of change over time.

El Malpais National Monument (ELMA)– El Malpais National Monument, located in west-central New Mexico, was established to preserve the nationally significant Grants Lava Flow, the Las Ventanas Chacoan Archeological Site, and other significant natural and cultural resources. El Malpais preserves and protects the natural and cultural resources of the unique lava fields and associated features. It also perpetuates this ecosystem for the benefit of present and future generations, for traditional cultural uses, and for long-term scientific inquiry. Inventory of plant and animal species of the monument will provide information for management decisions on resource issues, including the occurrence of rare, unclassified, and endemic species associated with the lava flows; the increase of visitor use, adjacent land development, and past land use. There is also a need to document the occurrence of species in the unique lava tube caves and other volcanic features that provide a variety of unusual habitats for biota.

El Morro National Monument (ELMO) – El Morro, located in western New Mexico, features a sandstone monolith rising 200 ft above the valley floor. This monolith, known as the Inscription Rock because it bears hundreds of inscriptions of Spanish explorers and early American immigrants and settlers. The monument also includes pre-Columbian petroglyphs and Pueblo Indian ruins. Proclaimed on December. 8, 1906 and including boundary changes on June 18, 1917 and June 14, 1950, the monument now consists of 1,040 acres federal and 240 acres of nonfederal lands. Inventory of plant and animal species of the monument would provide information for management decisions on resource issues, including the occurrence of rare and endemic species associated with the historic pool and box canyon.

Glen Canyon National Recreation Area (GLCA)– Glen Canyon lies in southern Utah and northern Arizona. The recreation area was established to provide for public outdoor recreation use and enjoyment of Lake Powell and adjacent lands adjacent, and to preserve and protect the scenic, scientific, and historic features contributing to public enjoyment of the area. Glen Canyon contains Lake Powell, the second largest man-made lake in North America, which provides both a unique opportunity to recreate in a natural environment and a transportation corridor to remote backcountry areas of Glen Canyon NRA. Glen Canyon National Recreation Area includes some of the most rugged and remote backcountry within the Colorado Plateau. The bench and upland areas support a wide variety of Colorado Plateau plant communities ranging from the dominant cold desert, shrub-grassland to cottonwood, willow, and tamarisk groves near flowing water, and juniper-pinyon woodlands at higher elevations. Most of these communities are located in areas classified as "Natural Zone" and recommended as suitable for wilderness designation. Aeolian and alluvial deposits and packrat middens provide information for paleo-environmental reconstruction and an understanding of climatic change. The recreation area encompasses upland and riparian habitat that supports populations of sensitive, endangered and threatened species including *Pediocactus bradyi*, *Cycladenia jonesii*, *Carex specuicola*, Peregrine Falcon , Bald Eagle, Southwestern Willow Flycatcher, Mexican Spotted Owl, Yellow-billed Cuckoo, Colorado squawfish, and razorback sucker. Found in the deep, narrow canyons, hanging gardens form along seeps in the canyon walls and in shaded plunge-basin riparian habitats and add interest, color, and diversity to the park. Evidence of 10,000 years of human occupation and use of resources within Glen Canyon NRA provides a continuing story of the prehistoric, historic, and present-day affiliation of humans and their environment. A complete inventory of the recreation area's biota would provide baseline information for the detection of changes due to livestock grazing, recreation (especially on water quality and aquatic ecology), and the effects of invasion of exotic species.

Grand Canyon National Park (GRCA) – Grand Canyon National Park is located in northern Arizona and encompasses a broad range of elevations and habitats. The park was established to preserve and protect the natural and cultural resources, ecological processes, and scenic, aesthetic, and scientific values of an area considered to be one of the natural wonders of the world. The park was also designated to provide opportunities for visitors to experience and understand the environmental interrelationships, resources, and values of the Grand Canyon, without impairing the resources. Grand Canyon National Park is also a World Heritage Site; it is nationally and internationally significant because of its geological and

biological resources, natural ecosystem processes, cultural resources, scenic qualities, natural quiet and solitude, and recreational opportunities. Inventory of the park's biological resources will provide information for planning for increases in visitor numbers (currently 5,000,000 visitors/year, 1,000,000/ year projected by 2030). There is also a need to restore forest conditions to prevent stand-replacing wildfires in the ponderosa pine forest, and to study the influence of controlled water flow on Colorado River corridor species. Inventory (and subsequent monitoring) will play an important role in the removal of exotic species where they occur and preventing invasion and spread of new species. Data from inventory will also assist in the completion of the wilderness management plan for certain areas of the park. Other natural resource priorities for the park include information on the occurrence, distribution, and abundance of major mammal species, including large predators, in the park. Inventory and monitoring also will provide information on spring environments, which are threatened by water wells tapping the underlying aquifer.

Hubbell Trading Post National Historic Site (HUTR) – Hubbell Trading Post is located in the Navajo Nation in northwestern Arizona. As a National Historic Landmark, Hubbell Trading Post is a unique example of a continuously operating Native American trading post. Pueblo Colorado Wash was the primary reason for establishing this cultural institution at its crossroads location. Inventory (and subsequent monitoring) will play an important role in enhancement and rehabilitation of the Pueblo Colorado Wash stream channel to a more sustainable system. Other natural resource management issues include removal of exotic species (Russian Olive and Tamarisk) from the riparian corridor, planning for the reintroduction of agriculture to the cultural landscape, re-establishment of native grasses on acres not used for farming, and management of the prairie dog community.

Mesa Verde National Park (MEVE) – Mesa Verde National Park is located in southwestern Colorado, and was established in 1906 to protect nationally significant archeological sites. The original enabling legislation included the mission to "… provide specifically for the preservation from injury or spoliation of the ruins and other works and relics of prehistoric…man contained within said park…" Over the years, Congress applied several amendments to the park's enabling legislation, to expand the park's boundary, and exclude hunting, trapping, fishing, mining and other incompatible uses. One of these amendments was 'An Act Accepting the Cession of Jurisdiction over Mesa Verde National Park to the United States Government, 1928'. Among other things, this law expanded the purpose of Mesa Verde National Park to include the "…preservation from injury or spoliation…[of]…all timber, natural curiosities, or wonderful objects within said park, and for the protection of the animals and birds in the park…" In 1976, the park's enabling legislation was amended again to include the management and protection of the Mesa Verde Wilderness. The Act of October 10, 1976, established 8,100 acres of wilderness in Mesa Verde, and expanded the purpose of the park to include management and protection of the three wilderness units "…in accordance with the applicable provisions of the Wilderness Act."

Major natural resource priorities include stabilization and restoration of natural areas in the wake of recent catastrophic wildfires. Inventory studies will facilitate park operations, compliance monitoring and impact assessment and mitigation. Information on species distribution and abundance is important in planning for restoration after construction projects, roadside vegetation trimming; and heavy erosion on backcountry roads. Impacts from travel to backcountry archeological sites need to be assessed and vegetation restored if necessary. Impacts on vegetation, springs, and geological resources during the stabilizing of backcountry archeological sites also need to be assessed, as well as the impacts of trail maintenance and trail. It is also important to document the extent of non-native plant invasion, and to prevent spread of already-present species and the introduction of new ones.

Navajo National Monument (***NAVA)*** – Navajo National Monument is located within the Navajo Nation, in northwestern Arizona. The primary purpose of the monument is to preserve and protect exceptional

cultural and natural environments that have a continuous human history. The purpose of the monument is also to contribute scientific and ethnographic knowledge and to provide resource-related educational and interpretive opportunities to the public. The monument represents the ongoing presence of human populations within the canyon ecosystem for a 1500-year period. The monument features some of America's most intact cliff dwellings and associated artifacts from the Tsegi Phase. These represent specific short-term (1250 – 1300) A.D. adaptations of the Kayenta Anasazi people from their agricultural life in open valleys into the canyon environment. Since establishment of the monument, local people have been instrumental in its exploration, development, and management. Betatakin Canyon shelters a protected relic aspen/fir forest community of highly diverse flora and fauna, including endemic species, threatened or endangered species, and other species of concern. This remnant forest is theorized to be similar to the setting when Betatakin ruin was occupied. Disconnected units away from roads have kept ruin sites remote, resulting in strong resource protection and a unique visitor experience centered on hiking and small guided groups. Inventory (and subsequent monitoring) will establish species presence and abundance for common species as well as species of concern. It will also provide information for management decisions regarding planning, mitigation, restoration, and removal of exotic species.

Petrified Forest National Park (PEFO) - Petrified Forest National Monument in north-central Arizona, was established by Presidential Proclamation No. 697 (34 Stat. 3266) on December 8, 1906. The original 60,776 acres were set aside because they were considered ". . . of the greatest scientific interest and value and it appears that the public good would be promoted by reserving these deposits of fossilized wood . . ." An Act of March 28, 1958 (72 Stat. 69) authorized the establishment of Petrified Forest National Park which ". . . shall be preserved and administered in its natural condition . . ." Petrified Forest National Park is globally significant for its exposures of fossils associated with the Chinle Formation. This fossil record provides information about a late Triassic Period ecosystem that existed more than 200 million years ago. Paleontological and stratigraphic information discovered on park land is an invaluable resource for the study of ancient organisms and their environment. On the other hand, information for understanding and managing the vegetation and wildlife of the Park is inadequate. Inventory studies will provide information on sensitive plant and animal species and their habitats and enhance management programs for pronghorn antelope and prairie dogs. Other resources issues that will benefit from better and more complete inventory data include fire history and the distribution and abundance of exotic species.

Petroglyph National Monument (PETR) – Petroglyph National Monument is located in central New Mexico within the city of Albuquerque. The monument was established to protect the array of petroglyphs created by Native Americans and early Europeans in the basalt boulders of the area. Changes in the surrounding lands are likely to affect natural resources within the monument boundaries; these changes include increasing development and the increase in the number of exotic species. Inventory (and subsequent monitoring) will allow managers to determine changes in ecological communities resulting from natural cycles as well as anthropogenic pressures. Other factors that will be addressed using data from inventory and subsequent monitoring include the role of fire on the grasslands within Petroglyph National Monument, and the effects of pollutants on species and ecological communities.

Rainbow Bridge National Monument (RABR) – Rainbow Bridge is located in southeastern Utah, and was set aside to preserve and protect the scenic, scientific, and historic features contributing to public enjoyment of the monument. Rainbow Bridge is the world's largest natural bridge, and is of great scientific interest as an example of eccentric stream erosion. To American Indian tribes, Rainbow Bridge is a sacred place that provides a link to traditional religious beliefs and their cultural identity. The monument is a small area that is contiguous with the much larger Glen Canyon National Recreation Area, which is responsible for management of Rainbow Bridge. Throughout the remainder of this proposal, Rainbow Bridge is lumped together with Glen Canyon for inventory priorities, planning, and fieldwork.

Salinas Pueblo Missions National Monument (SAPU) – Salinas Pueblo Missions, located near the Cibola National Forest in central New Mexico, once supported the thriving American Indian trade communities of Tiwa and Tompiro during the 17th century. However, by the late 1670s the entire Salinas District, as the Spanish had named it, was depopulated of both Indian and Spaniard. What remains today are the ruins of four mission churches, at Quarai, Abó and Gran Quivira. Established in 1980 through the combination of two New Mexico State Monuments and the former Gran Quivira National Monument, the present Monument comprises a total of 1,1071 acres. Natural resource needs are for aquatic biology studies and the identification of rare or unusual species associated with streams and wetlands.

Sunset Crater Volcano National Monument (SUCR) – Sunset Crater is located in north-central Arizona. The monument was established to preserve and protect geological formations, features, and resources for scientific interests and research, and for public interest including scenic, educational, and recreational pursuits. Sunset Crater Volcano is the Colorado Plateau's most recent eruption of the San Francisco Peak's volcanic field and is one of the longest-lived cinder cone volcanoes known in historic time, with an eruptive cycle that spans more than 100 years. The volcanic eruption profoundly affected people in the area and their lifeways and left a unique archeological and ethnographic record of human adaptation, response, and recovery to volcanic eruption. Sunset Crater Volcano and its natural resources continue to have cultural significance to contemporary native tribes. The park's volcanic features are seen now with few human disturbances and provide excellent opportunities for science, education and interpretation, including insight into plate tectonics, ongoing geologic and ecological processes, and a larger view of how this area is important in the context of southwestern U.S. and world geology. The micro-habitat and climate of Sunset Crater Volcano create an unusual species mix including lichens, molds, and endemic species that are highly visible examples of the theoretical concepts of succession and adaptation. There is a continuing need for research, data, inventory, and long-term monitoring at Sunset Crater, because of increased recreation pressure, encroachment of ORV use on park lands, and degradation of viewshed by mining and other activities. Additional factors are visitor use impacts and the invasion of exotic plants.

Walnut Canyon National Monument (WACA) – Walnut Canyon is located in north-central Arizona. The monument was established to protect the ancient cliff dwellings and associated resources that are of great ethnographic, scientific, and educational interest. The distribution, diversity, and location of sites in Walnut Canyon are unusual. The monument includes the only cliff dwelling architecture of the Northern Sinagua culture. Walnut Canyon provides vivid evidence of the Sinagua's ability to procure sufficient water to sustain life and grow crops. The natural and cultural resources within the monument are known to be significant to contemporary native tribes as evidenced by oral history and continuing practices and the archeological record. Within Walnut Canyon, ecological communities overlap to bring together species usually separated on an elevational gradient, creating a rare compression of plant and animal communities. The biodiversity supported by these habitats is thought to have contributed to the decision of prehistoric people to settle here. Topographic relief and biotic diversity make the canyon an outstanding scenic resource. Together with adjacent forest lands, the monument serves as a significant component of a designated greenbelt and natural sanctuary surrounding the city of Flagstaff. Historic railroad settlements, such as Flagstaff, contributed to Walnut Canyon becoming one of the first archeological areas to be heavily visited. Some sites record the extensive looting of this period. Today, due to management that emphasizes preservation, Walnut Canyon National Monument provides scientific opportunities to study irreplaceable cultural and natural resources. Encroaching development from the city of Flagstaff, increased recreational pressures, poaching of wildlife, and visitor use impacts have created needs for inventory and monitoring studies. Other natural resource issues include the effects of fire exclusion, pre-historic American Indian uses of the land, restoration of newly acquired land, loss of seasonal water flow, and impacts of Native American collection of wildlife and plants.

Wupatki National Monument (WUPA) – Wupatki National Monument, located in north-central Arizona, is the only known area in the Southwest where physical evidence from at least three archeologically separate ancestral Puebloan cultures is found together in a number of archeological sites. The natural and cultural resources within the monument are known to be significant to contemporary native tribes as evidenced by oral history, continuing practices, and the archeological record. Historic material reveals a rich record of human endeavor left by Navajo families over a period of 150 years and continuing through the present day, and by ranchers, sheepherders, prospectors, Mormons, the Civilian Conservation Corps, park custodians, and the Museum of Northern Arizona. Their activities, in addition to environmental changes, have created complex cultural landscapes within the monument. Wupatki protects one of the few native grasslands in the Southwest that is not being domestically grazed and its integrity is essential to perpetuating native species and natural ecosystem processes. There is a continuing need for research data, inventory, and long-term monitoring at this monument. Natural resource issues include exotic species invasions, and the assessment of effects of water withdrawals from the San Francisco peaks basin, long-term cattle grazing, fire exclusion, and Native American uses.

Yucca House National Monument (YUHO) – Yucca House, in southwestern Colorado, was established by Presidential Proclamation of December 19, 1919, to protect "…an imposing pile of masonry of great archeological value. . ." Data on plant and animal species are lacking at Yucca House. There is concern about livestock grazing and non-native weed infestations. Four hundred and sixty-nine ha (1200 acres) of surrounding agricultural and range land will be donated to the monument. Inventory and monitoring will be essential for determining the presence and abundance of plant and animal species, and providing baseline information for monitoring effects of potential spring depletions, invasion by exotic species, and restoration of newly-acquired lands.

2. Completed and ongoing biological inventory work in the parks

The following information was compiled and summarized based on a thorough review of published and unpublished reports, species lists, and other sources documenting species occurrence within the park units of the southern Colorado Plateau network. This review was conducted by a reference librarian and database technician hired as part of the proposal development phase of this project. The review included the extensive Natural Resource Bibliography (NRBIB) library database of published and unpublished references on natural resources in the parks, which was complete up to 1994, and also included review of published and unpublished reports and other data which has appeared since 1994. The project librarian updated the NRBIB database and annotated sources pertinent to inventory in the parks (see Appendix B, literature sources), and entered data on vertebrate and vascular plant species occurrence and documentation into the Park Service's NPSpecies database.

For some components of the flora and fauna, such as fish, birds, and vascular plants, little fieldwork will need to be done in a number of parks where adequate lists and distribution and abundance data already exist. For these areas, we have assembled databases in NPSpecies format that are relatively complete. Other areas and taxa that have incomplete inventory information (in some cases little or none) will be the target of inventory field work, as described in the methods sections later in this proposal. We will continue to update the NRBIB and NPSpecies databases over the course of the inventory program. In particular, subject matter experts will review the lists for all park units for their taxa, and make additions, corrections and further annotations. This will include voucher information from major regional museums for the southern Colorado Plateau, which we were not able to incorporate by the due date of this proposal.

The following section summarizes information from previous work available for each park. Annotated sources for these summaries are found in Appendix B. Table 2 (p. 32) summarizes initial estimates of percent completion of species inventories at each park.

2.1 Existing information

2.1.1 Birds

Aztec Ruins National Monument (AZRU)

Very little systematic natural resource inventory work has been conducted at Aztec Ruins National Monument. A survey for sensitive, threatened, and endangered species of Aztec Ruins National Monument was conducted under contract by Ecosphere Environmental Services, Inc. (1996). Fieldwork for this survey did not record any wildlife species, but the project report includes a hypothetical species list for plants and vertebrate animals for the AZRU area. This list includes eighteen bird species.

Bandelier National Monument (BAND)

A comprehensive and current bird list exists for BAND. This was compiled by Fettig (1999), and contains the results of research, observation, and expert review. The species list includes codes for relative seasonal abundance, where known. Birds of particular importance in the monument are the Mexican Spotted Owl (*Strix occidentalis lucida*) which uses the forests of the Jemez Mountains, and the Bald Eagle (*Haliaeetus leucocephalus*) around Cochiti Reservoir. BAND also includes nesting habitat for the Peregrine Falcon (*Falco peregrinus*). Ribe (1980) mentioned threats to the BAND populations of Merriam's Turkey (*Meleagris gallopavo*). Other previous bird research includes Jackson (1935), Collins (1950), Johnson's breeding bird study (1983), and studies of various raptors by Kennedy (1985-1993).

Canyon de Chelly National Monument (CACH)

The main source of information to date on the birds of CACH seems to be the wildlife checklist by Hasty and Fletcher (1981). The list (common names only) includes codes indicating relative abundance and occurrence. Of particular importance at CACH is the potential impact of area forest management and logging on the Peregrine Falcon (*Falco peregrinus*). An early report by Eaton (1937) describes birds of the Navajo Indian Reservation, their habitats, food, and nesting.

Chaco Culture National Historic Park (CHCU)

An annotated bird list by J. Cully (1985a) includes notes regarding occurrence and abundance, and is based on extensive field work at CHCU in 1978-1980. This work, however, does not include additions of land to the monument since then. The author also notes a deficiency in his documentation of wintering birds. A revised checklist of birds found in San Juan County may provide some additional information, but is not specific to the park. Field notes by Dines (1993) indicate some more recent investigation, but there is no record of a report from this study. Possible occurrence of endangered and sensitive species was reviewed in an in-house document ("Federal and New Mexico state threatened, endangered, & 'sensitive' species, Chaco Culture National Historical Park'" 1999). This list includes 6 bird species.

El Malpais National Monument (ELMA)

Lightfoot et al. (1994) include a bird species for El Malpais as an appendix to their vegetation and wildlife inventory report. This list has been updated by park staff, but still needs review. A checklist by Hvenegaard (1989) includes codes for abundance, seasonal occurrence, and habitats. Several unofficial references indicate potential habitat in ELMA for the Mexican Spotted Owl (*Strix occidentalis lucida)*.

El Morro National Monument (ELMO)

An electronic list provided by ELMO staff includes bird species, with most of the references being "Cibola, 1997." A few references are "FWS," and several, "DGF, 1996." Prior checklists include an annotated list by McCallum (1979) and a list by Stolz (1986). An Investigator's Annual Report (IAR) describes a one-day survey for the Mexican Spotted Owl (*Strix occidentalis lucida*) which found no evidence of nesting and no vocal response to calls. The report notes that habitat may be marginal.

Glen Canyon National Recreation Area (GLCA)

A current comprehensive list of the birds found at Glen Canyon National Recreation Area (La Rue and Spence, draft of early 2000) includes observations as recent as July 1999. The list is annotated, and includes comments on occurrence and relative abundance of selected species. Recent inventory work has covered most of the recreation area. Several studies and reports from the early 1990's (e.g. Boretti 1994) verify the occurrence of the Mexican Spotted Owl (*Strix occidentalis lucida*) in GLCA canyons. Numerous surveys for Peregrine Falcons (*Falco peregrinus*) have documented a large nesting population, along with some overwintering birds (Florian 1996). Lake Powell waterbird surveys were conducted between 1994 and 1998 (Spence 2000). Bald and Golden eagles **(***Haliaeetus leucocephalus***)** have also been monitored regularly at GLCA since 1990. More recently, a newly established colony of Great Blue Herons at Lee's Ferry has been monitored. Among other reports on the GLCA portion of the Colorado River below Glen Canyon Dam, Pinnock and Spence (1993) and Pinnock and Grahame (1994a, 1995a) report on waterfowl, and Pinnock and Grahame (1994b, 1995b) and Spence (1996) on breeding birds. Important baseline information collected before the filling of Lake Powell includes reports by Woodbury (1958, 1959) and by Atwood et al. (1980) which was based on literature, collections and field observations during 1971-1976 by investigators from Brigham Young University.

Grand Canyon National Park (GRCA)

One of the more recent checklists of GRCA birds is an annotated list by Brown (1985). This author has also provided a number of studies, particularly on the riparian birds of the Colorado River through Grand Canyon and their breeding ecology (e.g., Brown 1989). Brown and others have examined Peregrine Falcon (*Falco peregrinus*) populations, parasitism by the Brown-headed Cowbird (*Molothrus ater*), nesting of the Southwestern Willow Flycatcher (*Empidonax traillii extimus*), and more. A report by Feinberg (1991) notes no Mexican Spotted Owls (*Strix occidentalis lucida*) in a survey of two sites on the South Rim. However, Willey and van Riper (in progress) have surveyed areas of the North Rim and side canyons down to the Colorado River, and have found Spotted Owls in a number of areas. A recent reintroduction to the GRCA area is the extremely rare California Condor (*Gymnogyps californianus*), noted by Marshall (1994). Historic information on GRCA birds includes reports by Grater (1937), McKee (1937), and Merriam (1939). Birds from GRCA are included in specimen collections at the University of Arizona and the Museum of Northern Arizona, as well as the Park's own collections.

Hubbell Trading Post National Historic Site (HUTR)

A small pamphlet listing birds of Hubbell Trading Post is the only source known to current park staff for identification of species found there. The common-name list adds codes indicating relative abundance, status, and habitat; no author is given.

Mesa Verde National Park (MEVE)

An electronic list provided by current park staff gives common and scientific names for 152 bird species of MEVE, along with 29 species which are seen there rarely. This was compiled by the Air Resources Division for the AQUIMS database. Numerous in-house reports by MEVE staff member Marilyn Colyer (1990) cover annual surveys of Peregrine Falcons (*Falco peregrinus*), owls, and Bald Eagles **(***Haliaeetus leucocephalus***)**, along with studies of breeding and migrating birds, among other categories. Colyer

(1987) also has kept a series of field journals documenting natural resource observations at the park. A letter from Superintendent Heyder (1991) estimates five to eight pairs of Mexican Spotted Owls (*Strix occidentalis lucida*) in the park. Some recent studies have investigated birds of small sections of the park (Johnson 1995), (field notes and collections by Versaw 1982, 1988, 1990, 1991). One series of annual wildlife reports contains historic information from 1928-1975, and others contain information by park superintendents (incomplete series of monthly or annual reports from 1908 to at least 1991) and park naturalists (annually, 1930-1951).

Navajo National Monument (NAVA)

Little current work is available on birds of the Navajo National Monument; many of the existing papers were completed decades ago. A checklist of birds resulted from work by Brotherson (1980, 1981) in the Betatakin unit. Otherwise, most of the available documentation is from early work which covered a larger area and provides primarily suggestions of species which may occur. Bird studies in this category include those by Boyers (1934), Russell (1935), Eaton and Smith (1937), Wetherill and Phillips (1949), and Woodbury and Russell (1945). A recent work by Drost (2000) does report an investigation of threatened and endangered species of the monument, with recommendations for population monitoring of the Mexican Spotted Owl (*Strix occidentalis lucida*).

Petrified Forest National Park (PEFO)

Several recent lists of the birds of Petrified Forest National Park exist. One is a draft revised bird list of June 2000 (Colorado Plateau Field Station, 2000). In addition, a study by van Riper et al. (1999) covers grassland birds. An early report by Jenks (1929-1932) describes the life zones of Grand Canyon/San Francisco Peaks area, including the Little Colorado River valley and Painted Desert, and lists the birds associated with each zone, with a list of specific sites and breeding records. Checklists for the park were compiled by Stephenson (1959) and Johnson (1984). Bird voucher specimens are curated in the park.

Petroglyph National Monument (PETR)

A comprehensive survey was conducted in the mid-1990's to provide baseline biological information on the relatively new Petroglyph National Monument (Bleakly et al. 1996). The report contains sections written individually by specialists from the University of New Mexico describing the inventory processes and listing species recorded. This report includes a bird checklist.

Salinas Pueblo Missions National Monument (SAPU)

Little information has been reported on the birds of Salinas Pueblo Missions National Monument. A study by Scott (1979) included a bird list, but a letter from the New Mexico Department of Game and Fish (Hubbard, 1980) criticizes the bird portion of this report. Besides some observations, a 1956 checklist (author unknown) seems to be the only other historical source.

Sunset Crater Volcano National Monument (SUCR)

Surveys and ecological studies were conducted at Sunset Crater and Wupatki National Monuments by staff and students from Northern Arizona University, and are detailed in a series of reports that include information on birds (Bateman 1976). An additional result of these studies is a bird checklist (Balda and Beatty 1976). Surveys for birds were limited in intensity and coverage, however. Data for Sunset Crater and Wupatki are lumped in data tables and are not presented separately, which greatly limits their usefulness for inventory information. Nonetheless, data from these studies provide potentially useful comparative information for the species that were documented. Slightly earlier bird checklists were compiled by Magee (1969, 1970). Both of these lists contain information on occurrence and frequency. A combined National Park Service list for SUCR and WUPA (1990) is the only later information in NRBIB.

Walnut Canyon National Monument (WACA)

Early material regarding birds of Walnut Canyon National Monument includes a published bird list (Grater 1936), and a paper by Spangle and Spangle (1954) with descriptions and drawings. Discussion in this paper covers the plant-avian relationships in the canyon, as well. Haldeman and Clark (1969) also investigated this relationship in light of the high variety of plant communities within Walnut Canyon which has led to an unusual avian community residing in the canyon. Ganey (1988, 1992) did some of the research for reports on the Mexican Spotted Owl (*Strix occidentalis lucida*) at WACA. In addition, work by Nagiller and Randall (1988) documented the number, sex, and nesting status of observed Mexican Spotted Owls in an area at the western boundary of Walnut Canyon. The only recent checklist appears to be one by the National Park Service (1985) listing common names, with information on residence status and relative abundance.

Wupatki National Monument (WUPA)

Reports by Bateman (1976, 1980) and by Balda and Beatty (1976) provide preliminary survey information for Wupatki National Monument. These reports identified species occurring in different vegetative zones and attempted to relate these patterns to vegetation and insect / food abundance. Surveys were not thorough, however, and were limited in area covered. Further, species occurrence data were lumped with data from nearby Sunset Crater National Monument, limiting the usefulness of the information for inventory purposes.

An update by Balda (1984, unpublished) indicates bird abundance and occurrence, with notes and deletions. A typewritten checklist with this contains comments on abundance, along with dates and locations of sightings (at both WUPA and SUCR). Work by Howk (1982) includes a checklist of WUPA birds with indication of the abundance and occurrence of each species. Some additional information for Wupatki is available in reports on individual species or groups; these include reports by Phillips (1947) on hawks and owls, and by Brown and Brown (1990) on cooperative breeding of Pinyon Jays (*Gymnorhinus cyanocephalus*). The only recent checklists appear to be those by the National Park Service (1985, 1990) intended for visitors.

Yucca House National Monument (YUHO)

Richert and Brandegee (1941) provide an early bird list for YUHO, with common and scientific names, and relative frequency. An up-to-date list has been compiled by Colyer (MEVE staff) from in-house records and observations. This list includes indications of habitat, relative abundance, residency and nativity status. Other available recent information consists only of informal lists including a narrative list by Versaw (1990).

2.1.2 Mammals

There are no federally threatened or endangered mammals on the Colorado Plateau other than the black-footed ferret and the Utah prairie dog. However, states that manage wildlife on the Colorado Plateau have developed lists of species of concern. These lists are somewhat idiosyncratic but include many species of legitimate concern. In particular, bats as a group are generally perceived as declining in numbers although precise data documenting long-term population declines in western bats are not available. In addition, some shrews, pikas, gophers, pocket mice, kangaroo rats, and squirrels are variously listed by the states. Typically, rigorous data documenting declines are not available; many of the species are frequently peripheral within a given state and this accounts for their listing within that state.

Dominant species of the Colorado Plateau include several species of *Peromyscus* (deer mice and white-footed mice, which in some areas may account for 70% or more of captured small mammals), a modest variety of ground squirrels, three species of lagomorphs, and deer and elk. Carnivores often seem thinly scattered, but this may reflect their secretive habits. In some parks (e.g., MEVE), away from people, carnivores (foxes, bears, mountain lions) are frequently seen.

One concern raised about mammals during the subject matter experts' meeting in Moab was the extent to which records of mammals for a given area may be transitory or ephemeral in nature. We know of no specific studies that address this on the plateau or elsewhere, but our general impression is that unlike the Great Plains and Gulf Coast where some species of mammals have expanded their range during mild winters only to retract in more severe ones, ranges of mammals on the plateau are relatively stable. Bats are somewhat more unknown in this regard. Uncertainties about occurrence of most mammals on the plateau are more a function of insufficient sampling for mammals, failure to retain voucher specimens that attest to the occurrence of a species, misidentification of a species when in hand, or a misunderstanding of taxonomy. We are of the view that most species of mammals on the plateau still reside at historic localities with the exception of those mostly large carnivores (e.g., grizzly bear, gray wolf) that have been extirpated from the region.

Aztec Ruins National Monument

The flora and fauna of Aztec Ruins NM have received almost no systematic inventory work. Field work for a survey for sensitive, threatened, and endangered species (Ecosphere Environmental Services 1996) covered only about 4 acres of the Monument. Although the project report notes that no wildlife was seen, it provides a hypothetical species list for the area, as an appendix. This list includes 13 mammal species.

Bandelier National Monument

Mammal inventory information for Bandelier NM is based on studies of specific taxa, and compilations of existing published and unpublished information; there has not been a broad, systematic survey of the mammal fauna. The most recent compilation for the Monument is the park checklist, Vertebrates of Bandelier National Monument (1990). Guthrie and Large (1980) summarized data on distribution and frequency of mammals within Bandelier NM, drawing primarily on sightings by park personnel and visitors prior to September 1979. Individual research studies include an extensive survey of bats, which provided data on the occurrence and biology of 14 bat species in the Bandelier area (Bogan et al. 1997, 1998).

Canyon de Chelly National Monument

The most recent compilation on the mammals of Canyon de Chelly is Hasty and Fletcher (1981), which includes a listing of all vertebrates known from the area, including mammals. Other, limited work on the mammal fauna of Canyon de Chelly includes surveys by Burgess (1970), who documented observations and trapping results from several sites in the Monument.

Chaco Culture National Historical Park

Individual research projects pertaining to mammal inventory at Chaco Culture NHP include J. Cully (1981), which analyzes distribution and abundance of small mammals from trapping data for four habitat types within the Monument; Jones (1972), which also discusses small mammal trapping data; and bat surveys by Valdez et al. (1999), including data on occurrence and numbers caught in mist net sampling. A compilation of federal and New Mexico state threatened, endangered, and "sensitive" species by Chaco Culture NHP (1999), lists 9 mammal species considered "sensitive" by a state or federal agency, which may occur in the Monument.

El Malpais National Monument

Surveys for bats by Valdez et al. (1999) documented distribution of species by habitat, relative abundance, and data on reproduction and activity use of the ANABAT system for analyzing bat calls, and collection of guano and ectoparasites for analysis. This study collected data through mist-net capture and ultrasonic surveys (ANABAT).

El Morro National Monument

No systematic mammal survey has been conducted at El Morro NM. A checklist document, Mammals of El Morro National Monument (1986), summarizes known records and observations. This document lists 73 species of mammals, of which 38 have actually been recorded within the Monument. The remaining 35 have been found in the vicinity of El Morro.

Glen Canyon National Recreation Area

There is a recent checklist of mammals for Glen Canyon National Recreation Area (Glen Canyon National Recreation Area, 1998) based on records and reports from a variety of studies and observations. There has been no comprehensive inventory study of mammals at Glen Canyon NRA. The studies that have been conducted looked at specific taxa, or limited areas of the Recreation Area. Bogan (1994) describes bat surveys at a number of areas on the Colorado Plateau, using mist nets and ultrasonic call detectors. His surveys document nine species of bats at GLCA, with two other species listed as possible based on old records. Recommendations are included for monitoring programs. Bogan and Ramotnik (1995) describe surveys of mammals in four riparian areas at GLCA. They include a preliminary list of Glen Canyon mammals (with notation of pertinent records) and a 1994 capture summary by location. Spence (1999) reviews and summarizes special status species and habitats at GLCA. His list includes two state special status mammal species: the Townsend's big-eared bat and the spotted bat.

Grand Canyon National Park

There has been surprisingly little work on the mammals of Grand Canyon National Park, particularly in areas away from the Colorado River. The checklist by Butterfield et al. (1981) lists 88 species, of which 14 are listed as 'hypothetical' (suitable habitat present, but no verified records). A catalog of the mammal collection at Grand Canyon NP (Burgoon, 1966) dates from 1928, and includes 784 individual animals representing about ninety species and subspecies. Most specimens are from Grand Canyon NP, but also represent specimens from the 1936 Hall Expedition in the Rainbow Bridge-Navajo National Monument areas. Surveys of riparian habitats along the Colorado River, conducted during raft trips through the canyon, have focused primarily on small mammals (Ruffner et al. 1978, Suttkus et al. 1976, 1978). These surveys documented 31 mammal species in the area along the river. Hoffmeister and Durham (1971) conducted field surveys and compiled existing information (from museum specimens) on mammals of the Arizona Strip region of northwest Arizona, encompassing part of Grand Canyon National Park. They list 60 species for this region, of which eight are listed as hypothetical.

Hubbell Trading Post National Historic Site

Hubbell Trading Post National Historic Site has received virtually no scientific survey work on its mammal fauna. The limited information in the site's databases is from scattered, unverified sources, and the list of mammal species has not received critical review.

Mesa Verde National Park

A series of reports (Bogan 1990-1992, Bogan and Ramotnick 1993, Ramotnick and Bogan 1995) describe inventory fieldwork for mammals at Mesa Verde NP. In particular, these surveys have provided valuable new data on the small mammals (including bats) of MEVE. Their surveys documented and provided ecological information on four shrew species at the park, as well as 11 of 16 known or suspected bat species. In addition, they collected medium-sized mammals, and recorded observations of large

mammals. The reports also review and update the mammal species list for MEVE. Bogan (1994) summarizes occurrence data on bat species at MEVE and other Colorado Plateau park areas.

Navajo National Monument

Because of the emphasis of Navajo National Monument on cultural resources, the natural resources of the monument are rather poorly known. There have been overview studies of the flora of the area, along with ecological studies of the vegetation (e.g., Brotherson et al. 1978, 1985, Robinson 1986). Limited work on animal species includes lists of birds, mammals, reptiles, and amphibians (Brotherson et al. 1977, 1980, 1981, Clark 1935). Woodbury (1963) listed some of the plants and vertebrate species of NAVA, along with a list of insects and mollusks. The species lists provided by these various sources are not complete, as evidenced by subsequent addition of other species found at the Monument. Drost (2000) conducted an intensive survey of threatened, endangered, and other special status species at NAVA. Most of the mammal portion of this study was directed at bat surveys using mist netting and ultrasonic call detectors. A total of eight bat species was documented during the survey, and detailed information is provided on the five that are former U.S. Fish and Wildlife Service 'C2' species (Long-eared, Long-legged and Yuma Myotis, Townsend's Big-eared Bat, and Spotted Bat). Among the 4 appendices is a list of the species sought during the survey, along with detailed field notes listing species found by location.

Petroglyph National Monument

A survey of the biological resources of Petroglyph National Monument lists 28 mammal species based on field observations and collections at the Museum of Southwestern Biology at the University of New Mexico. The report notes the number of specimens archived in the Museum.

Petrified Forest National Park

Information on the mammal fauna of Petrified Forest National Park (as of the early 1980's) was compiled by Cockrum (1986). This is a useful comparative source for future inventory and population monitoring studies, and includes summary species accounts, North American distribution maps, and Park voucher maps for each species. More recent surveys have been conducted by the U.S. Geological Survey (Ramotnik and Bogan, 1998). This work consisted of baseline inventory of mammals at Petrified Forest National Park during 1996-1997. Sampling methods included mist netting for bats and trapping for small ground mammals. Specimens were also salvaged along the roads, and tracks or scat of larger mammals recorded. The report gives annotated species accounts for mammals captured or observed in the park, and an updated list of Petrified Forest mammals.

Salinas Pueblo Missions National Monument

Salinas Pueblo Missions National Monument has not received any systematic survey of its mammal fauna. The limited information in the site's database is from unverified sources, and the list of mammal species has not received critical review.

Sunset Crater Volcano National Monument

Surveys and ecological studies were conducted at Sunset Crater and Wupatki National Monuments by staff and students from Northern Arizona University, and are detailed in a series of reports that include information on mammals (Bateman 1976, 1980). Mammal surveys were mainly limited to trapping for small mammals, however, and were limited in intensity and geographic coverage. Also data for Sunset Crater and Wupatki were combined, with no separate listing of species, abundance or ecological data for the two monuments. Nonetheless, data from these studies do provide some potentially useful comparative information for the species that were documented. A thesis study (Lincoln 1961) compared past and present mammal fauna of the two monuments, and includes a table of mammal species known from the general Wupatki / San Francisco Mountains region. Little other work on mammals has been

conducted at Sunset Crater.

Walnut Canyon National Monument

Most of the inventory work at Walnut Canyon has focused on the flora of the area, with little work on the animal fauna. A listing of mammal species is available (Salomonson 1973, reprinted as a 1985 park checklist), but this was based on limited field work and existing records. Recent unpublished studies are beginning to add to what is known of mammals at Walnut Canyon (e.g., bat surveys, C. A. Drost, unpublished report), but the area remains poorly known.

Wupatki National Monument

As noted above several interrelated natural resource studies were conducted at Sunset Crater and Wupatki National Monuments by Northern Arizona University, and are covered in a series of reports that provide some data on mammal species at Wupatki (Bateman 1976, 1980). The mammal surveys were quite limited, however. Except for some baseline population data on particular small mammal species, this work did not provide good mammal inventory information. Also as noted, Lincoln (1961) compared past and present mammal fauna in the Sunset Crater / Wupatki area, and provides a regional list of mammal species. Hoffmeister (1986) includes a number of specimen records for Wupatki, but these are scattered throughout the general species accounts in that work.

Yucca House National Monument

No systematic mammal surveys have been conducted at Yucca House National Monument. A mammal species list is available for the area, updated as of January 2000. However, this list is based solely on in-house observations and a compilation of various other unpublished sources. The list has not received critical review, and is evidently incomplete (e.g., bats are simply listed as "Vespertilionidae" – unknown species). Systematic inventory work is needed to provide a reliable, relatively complete list.

2.1.3 Amphibians and Reptiles

Aztec Ruins National Monument

Very little systematic natural resource inventory work has been conducted at Aztec Ruins National Monument. A survey for sensitive, threatened, and endangered species of AZRU was conducted under contract by Ecosphere Environmental Services, Inc. (1996). Fieldwork for this survey did not record any wildlife species, but the project report includes a hypothetical species list for plants and vertebrate animals for the AZRU area. This list includes six reptile species.

Bandelier National Monument

Wauer and Fletcher (1974) reviewed the known occurrence of amphibians and reptiles at Bandelier National Monument, and in the adjacent Jemez Mountains and Rio Grande Valley. A broad scale field inventory study of the amphibians and reptiles of BAND was conducted by Degenhardt (1975). This survey documented species occurrence, relative abundance, distribution, and habitat relationships of the amphibians and reptiles in and around the Monument. Much research has been conducted on distribution, numbers, habitat and ecology of the Federally Endangered Jemez Mountains salamander (*Plethodon neomexicanus*), which has much of its restricted geographic range within BAND (Allen and Touchan 1994, Guthrie 1978, 1979, Wauer 1978). Other studies have provided information on amphibians and reptiles in grassland habitats (Allen 1984), and amphibians in some of the canyons within the Monument (Guthrie 1976).

Canyon de Chelly National Monument

The main source of systematic survey information for amphibians and reptiles at Canyon de Chelly is Burgess (1970). However, those surveys were limited to a few sites over part of one amphibian and

reptile activity season. The species list from this report is probably most deficient for the snake fauna of the Monument.

Chaco Culture National Historic Park

Preliminary data on species occurrence and basic ecology of amphibians and reptiles of Chaco Culture NHP is provided by Jones (1970). This thesis includes an annotated list of amphibian and reptile species from the Monument. These data form a useful baseline for the species included, but the survey was based on only six weeks of field surveys, and did not include recent additions to the Monument. Possible occurrence of endangered and sensitive species was reviewed in an in-house document ("Federal and New Mexico state threatened, endangered, & 'sensitive' species, Chaco Culture National Historical Park," 1999).

El Malpais National Monument

Lightfoot et al. (1994) include a species list of amphibians and reptiles of El Malpais as an appendix to their vegetation and wildlife inventory report. This list has been updated by park staff, but still needs review.

El Morro National Monument

Lightfoot et al. (1994) also include a species list of amphibians and reptiles from El Morro National Monument. McCallum (1979) provided descriptions and general ecological information on amphibians and reptiles known from El Morro. Stolz (1986) gave an updated species list, including nine species that occur near the Monument, but had not yet been recorded within NPS boundaries.

Glen Canyon National Recreation Area

No comprehensive surveys have been conducted of the amphibian and reptile fauna of Glen Canyon National Recreation Area. The studies that come closest (Tanner 1958, Woodbury 1959, Woodbury et al. 1959) were based primarily along the Colorado River in Glen Canyon, or on the Navajo Reservation south of the river (Eaton 1935). These studies are old (based on data collected 40-60 years ago), but provide valuable comparison information, particularly for conditions before Glen Canyon was inundated by Lake Powell. A number of other studies provide information on certain areas within GLCA, or on specific amphibian and reptile taxa. These include Atwood et al. (1980) and Hevly et al. (1973) for the fauna of the Kaiparowits Basin, Clark (1935) for the area of Navajo Mountain, Cole (1935) for the Rainbow Bridge area and the south side of the river, and Mueller et al. (1998) for the lower Escalante River. A number of reports have discussed occurrence, numbers, and habitat of northern leopard frogs, including Craig and Pinnock (1995), Drost and Sogge (1993), and Spence (1996).

Grand Canyon National Park

Dodge (1938) is a useful historical reference on amphibians and reptiles of Grand Canyon National Park. Most amphibian and reptile survey work in Grand Canyon has also been confined to the area immediately along the Colorado River. A number of studies have sampled and recorded amphibians and reptiles along the entire course of the river through Grand Canyon National Park (Aitchison et al. 1974, Carothers et al. 1976, Miller et al. 1982, Suttkus et al. 1976, Warren and Schwalbe 1985). Taken together, these studies provide a relatively complete overview of species occurrence, relative abundance, and habitat of amphibians and reptiles in areas near the river. Other studies that have reported on specific other areas of the park include Durham (1976, North Rim), Rasmussen (1941, Kaibab Plateau), and Sherbrooke (1966, Mount Trumbull and Toroweap Valley area). A variety of research studies have also been conducted on specific taxa or groups. Those pertinent to inventory include Gehlbach (1969, tiger salamander), Tomko (1976, lizard ecology) and Young and Miller (1981, Grand Canyon rattlesnake).

Mesa Verde National Park

The most complete compilation of amphibians and reptiles for Mesa Verde is that of Douglas (1966). This report was part of an archaeological survey project for the park, and includes general descriptions and data on species occurrence and distribution. Other studies that have reported on amphibian and reptile species occurrence, distribution, and abundance include Bogan (1993) and Colyer (1989). Other studies pertinent to amphibian and reptile inventory include M'Closkey (1990, 1991), who studied the distribution and abundance of lizard species at the park, and effects of fire. Of potential value as historical baseline information are a succession of reports by park naturalists (Quaintance 1935, Watson 1940-1946).

Navajo National Monument

Little specific survey work for amphibians and reptiles has been conducted at Navajo National Monument. A number of older, broad-scale surveys of Navajo Reservation lands include some notes on the units of Navajo National Monument (Cole 1935, Woodbury et al. 1959). Two more recent studies contain some data on amphibians and reptiles at NAVA, but this pertains only to the Betatakin unit (Brotherson et al. 1977, Woodbury 1963). A survey of threatened and endangered species at the monument (Drost 2000) includes notes on amphibian and reptile species.

Petrified Forest National Park

Most of our knowledge of amphibian and reptile species occurrence, distribution, and abundance come from a two-year inventory study in 1997 – 1998 (Drost et al. 2000). This survey used a variety of field sampling methods, including visual encounter surveys, pitfall trapping, artificial cover boards, and night driving. Sampling included comprehensive geographic, habitat, and seasonal coverage, and yielded two new species previously unreported at Petrified Forest. Additional reports (Persons and Wright 1999a and 1999b) provide detailed information on particular species at PEFO.

Petroglyph National Monument

A comprehensive survey conducted in the mid-1990's to provide baseline biological information for the relatively new Petroglyph National Monument (Bleakly et al. 1996). The report contains sections written individually by specialists from the University of New Mexico describing the inventory processes and documenting species recorded, including a list of reptiles and amphibians.

Salinas Pueblo Missions National Monument

No systematic surveys of amphibians and reptiles at Salinas Pueblo Missions have been reported. Some information has been reported on individual species (e.g., Howell 1957, prairie rattlesnake).

Sunset Crater Volcano National Monument

Surveys and ecological studies were conducted at Sunset Crater and Wupatki National Monuments by staff and students from Northern Arizona University, and are detailed in a series of reports that include information on amphibians and reptiles (Bateman 1976, 1980). Surveys for amphibians and reptiles were limited in intensity and geographic coverage, however, and data for Sunset Crater and Wupatki were combined, limiting their usefulness. Data from these studies provides potentially useful comparative information for the species that were documented.

Walnut Canyon National Monument

Very little published data are available on the occurrence, distribution, and abundance of amphibians and reptiles at Walnut Canyon National Monument. Recent unpublished work has begun assembling the scattered observation and specimen data that are available at the Monument and at local museums. Persons and Bradley (2000) report on one new species occurrence at WACA.

Wupatki National Monument

Reports by Bateman (1976, 1980) provide preliminary survey information for Wupatki National Monument. These reports identified species occurring in different vegetative zones and attempted to relate these patterns to vegetation and insect abundance. Surveys were not thorough, however, and were limited in area covered. Further, species occurrence data were lumped with data from nearby Sunset Crater National Monument, limiting the usefulness of the information. Recent studies and reports on individual species provide some additional information for Wupatki; these include Persons (1999a, 1999b).

Yucca House National Monument

Only limited information on amphibian and reptile species is available for Yucca House National Monument, and no systematic surveys have been conducted. General fauna and flora lists for the monument include amphibians and reptiles (Anonymous 1990, Richert and Brandegee 1941). Some additional information is available for individual species (Quinn 1984, western rattlesnake).

2.1.4 Fish

Many of the small National Monuments and Historic Sites within the southern Colorado Plateau network have no perennial water, and hence no fish. On the other hand, in the large parks that include major rivers and streams (e.g. Glen Canyon National Recreation Area, Grand Canyon National Park), the fish fauna has been studied intensively because of changes caused by dams and reservoirs, the severe endangerment of most of the native fish species, and because of fishery interest in stocked species such as trout and striped bass. The inventory advisory group and park service representatives agreed that, for basic inventory purposes, the units within the southern Colorado Plateau network had received adequate coverage for fish. Additional work is needed in some areas on the population status and ecology of specific native fish species. The following sections describe studies in southern Colorado Plateau park units that do have fish.

Bandelier National Monument

Several studies have provided surveys of fish species at Bandelier (Pilz et al. 1979, Platania 1991a and 1992), and notes on regional distribution (Platania 1991b). The most recent species list is Bandelier N.M. (1990). Other reports include a review of reservoir operation in relation to impacts on fish and other natural resources (Allen et al. 1993), reintroduction of cutthroat trout and associated research (National Park Service 1978), impacts on stream habitat in the region (Propst and Miles 1975) and contaminant loads (including DDT) of resident fish (Fletcher 1994, Marron 1989)

Canyon de Chelly National Monument

Limited perennial water within Canyon de Chelly National Monument consists of a short stretch of Chinle Wash and its tributaries. A survey and list of fish species in the monument was provided by Burgess (1970).

Glen Canyon NRA

The primary water areas in Glen Canyon National Recreation Area are the vast area of Lake Powell, a short stretch of the Colorado River below Glen Canyon Dam, and a few large tributaries to Lake Powell, such as the Escalante River. Studies of the fish fauna of Lake Powell include general distribution and habitat (Gloss 1970, Harris 1963, Holden 1973), and sport fishery (Gloss 1971, Stone and Rathbun 1968). The reports by Glen Canyon Environmental Studies (see below, under Grand Canyon NP) also cover the stretch of the Colorado River between Glen Canyon Dam and Lees Ferry, which is within Glen Canyon NRA. Other studies have looked at contaminant loads in the fish in Lake Powell (Lowe et al. 1985), and

specific contaminants such as mercury (Potter et al. 1975). Additional work is needed for occurrence and ecology of fish species in the Escalante River.

Grand Canyon National Park

A large series of reports and papers by Glen Canyon Environmental Studies investigate the ecology of fish in the Colorado River, and the effects of dam operations on the fish and their habitat, including the aquatic food base, native / non-native species interactions, spawning and nursery habitat. Other studies include general distribution and life history (Holden 1973, Kaeding and Zimmerman 1983, Usher et al. 1980), movements (Valdez 1993), trophic interactions (e.g. Angradi 1994, Shannon et al. 1994), genetic studies of individual species (e.g. Dowling et al. 1993), and studies of single species (Leibfried 1991, Minckley 1985, Valdez et al. 1993, Weiss 1993). A number of studies focus on the Little Colorado River in relation to the native fish fauna (e.g. Gorman et al. 1993). A few studies have looked at the occurrence and ecology of fish in tributary streams, including Shinumo Creek (Allan 1993), and Bright Angel and Kanab Creek (Otis 1994).

Mesa Verde National Park

The Mancos River, within and adjacent to Mesa Verde, is the main perennial water of Mesa Verde National Park. Fish studies in the river have been conducted by the U.S. Fish and Wildlife Service (1976, 1986, 1993, 1994)

Wupatki National Monument

The only perennial stream within any part of Wupatki National Monument is the Little Colorado River, which forms a small part of the northeastern boundary of the monument. One fish species has been recorded in the Little Colorado adjacent to the monument – the plains killifish (*Fundulus zebrinus*), which is an introduced species (Wupatki National Monument museum collection).

2.1.5 Vascular plants

Aztec Ruins National Monument

Very little systematic natural resource inventory work has been conducted at Aztec Ruins National Monument. A survey for sensitive, threatened, and endangered species of the Aztec Ruins National Monument area was conducted under contract by Ecosphere Environmental Services, Inc. (1996). Fieldwork for this survey of a 4-acre tract adjacent to the Monument recorded 35 species of grasses, forbs, trees, and shrubs. Clark (1950) recorded plants of the Sonoran zone in the AZRU region, but this is not a complete listing of the flora of the area. In all, 11 vegetation types have been reported, ranging from pinyon-juniper woodland, grasslands, to riparian vegetation types.

Bandelier National Monument

This park is typified by complex terrain and vegetation. In all, 15 vegetation types have been recognized, most of which are forest and woodland types. The vegetation and flora have affinities primarily with the southern Rocky Mountains rather than the Colorado Plateau. The primary current source regarding plants of Bandelier National Monument is Jacobs (1989a). This author has also provided a historical review of the Monument herbarium which contains over 1600 specimens, including sensitive species (Jacobs 1989b). Supplementing work done within the Monument, botanical studies at the adjacent Los Alamos National Environmental Research Park (NERP) extend information available on area plants. A volume by Foxx and Tierney (1980) describes the status of the flora at the research park. Fire ecology is also an important part of plant study in this area (Foxx and Potter1984; Potter and Foxx 1986). For historical comparisons, Fulton printed a Bandelier flora list in the Southwestern Monuments Monthly Report (Fulton 1935). Information on the distribution and abundance of three special status species – *Botrychium multifidum*, *Cypripedium calceolus*, and *Lilium philadelphicum var. andinum*– is needed.

Canyon de Chelly National Monument

The two chief sources of information on the plants of Canyon de Chelly are both from the 1970's (Halse 1973; Harland and Dennis 1976). The latter paper identifies seven plant habitat types, with a plant checklist. A record in NRBIB describing the Monument's herbarium mentions several hundred specimens.

Chaco Culture National Historic Park

A recent plant study at Chaco Culture NHP by Floyd-Hanna and Hanna (1995) also includes results of an important earlier study by A. Cully (1985); both reports contain lists of the species documented to that time. Potential special status plants in the park appear in a list compiled by park staff from several sources (Chaco Culture National Historical Park, 1999), but the summary concludes that suitable habitat occurs within the park for only four of the seventeen potential species. Rangeland Resources International, Inc. (1978) also investigated special status plants of the San Juan-Chaco area, incorporating an herbarium search and literature review, and providing a plant list for this broader area. An older source is Potter (1974) which reports on limited plant surveys (transects in several sections of the park), but does provide descriptions of vegetation types, plants, soil preferences, and responses to grazing for these areas. The park lacks a vegetation map, but nine vegetation types have been documented, including an unusual spring-supported rincon community. Information is deficient on the status and distribution of four rare natives: *Aletes macdougalii*, *Astragalus micromerius*, *A. naturitensis*, and *A. oocalysis*. In addition, more information is needed on the abundance and distribution of several exotic species, including *Bromus tectorum*, *Centaurea diffusa*, *Halogeton glomeratus*, and *Tamarix chinensis*.

El Malpais National Monument

Lightfoot et al. (1994) include a species list of plants of El Malpais as an appendix to their vegetation and wildlife inventory report. A thesis of the same year by one of these authors (Bleakley, 1994) also focuses on the plants of ELMA. The resulting plant lists have been updated by park staff, but still need review. In addition, an estimated 12,150-16,200 ha in remote areas remains un-inventoried. A brief undated record in NRBIB mentions an ELMA collection, including plant specimens, at the University of New Mexico. It was expected that part of that collection would be moved to the monument. A park checklist for visitors was compiled by Ott-Jones (1989). Specialized examinations of monument plants include Carlton (1988), which examines the species commonly associated with the lava tube systems at ELMA; this paper also notes that the included list is incomplete. This park is characterized by an unusual landscape and affinities with the Chihuahuan Desert. Francis and Williams (1989) briefly describes 19 plant communities of the monument, and Spellenberg (1979) states that no threatened or endangered species were found in an investigation of the Grants Malpais.

El Morro National Monument

An electronic list provided by ELMO staff includes plant species. McCallum (1981) and Stolz (1986) are the primary references for this list. A few references are "FWS, 1995" and several, "Schackel, 1984." An historical look at the vegetation is provided in Schackel (1984) through the use of comparison photography; the photographs show 100 years of effects from human activity at the Monument. Areas of concern include overgrazing, fire suppression, plant growth, and the incursion of pinyon-juniper woodland into the grassland community. The Monument does have an herbarium collection, but the number of specimens included is not available.

Glen Canyon National Recreation Area

This is the largest park unit in the network, with 507,618 ha. Vegetation is complex, especially in riparian zones and springs, with a total of 37 vegetation types documented to date (Spence 1995, 1996, 1997b, 1998a). Because of its size, GLCA has not had complete floristic surveys. Floristic information is

inadequate for an estimated 101,250-121,500 ha. The park checklist (Spence and Zimmerman 1996), based largely on Welsh (1984) and Schultz et al. (1987), lists 785 species and ca. 100-120 additional species that occur in surrounding areas and are likely to occur in GLCA. Out of a total of 38 special status native species known from the NRA, at least 17 are known to occur or could be found in areas not yet sampled (Spence 1999).

The wide range of habitats in the extensive area of GLCA accommodates a variety of special plant communities; reports describe investigations of hanging gardens (Spence, 1995), the Tropic Shale and Dakota formations (Atwood, 1992), riparian areas below Glen Canyon Dam (Carothers et al. 1981) and other such specific habitats. Spence (1992, 1999) describes the sixteen known federally listed or candidate species of GLCA, and lists, as well, other species in the region which may eventually also be found within Glen Canyon National Recreation Area. A Brigham Young University dissertation (Neese, 1981) describes the vascular flora of the Henry Mountains, including the structural basin which extends to Lake Powell. The annotated checklist for this portion of GLCA is based on field collections by the author, on other specimens at Utah universities, and on documented literature citations. A 4-volume set by Welsh (1984) provides extensive preliminary botanical information for GLCA, including results of surveys for rare plants, hanging gardens, and general flora. Appendix I is a checklist of plants based on this study, literature review, and the Glen Canyon NRA herbarium specimens at Brigham Young University. Appendix II contains species lists compiled at survey sites visited during this study. Appendix III (2 vols.) includes a printout of all collection data from Glen Canyon NRA and adjacent areas on file in the computer at the BYU herbarium (including, but not limited to, this survey). Earlier herbarium collections were made by Gaines (1960), and sent to the Herbarium at the Museum of Northern Arizona in Flagstaff, and to the Herbarium of Washington State University at Pullman. The recreation area maintains a list of herbarium specimens.

Grand Canyon National Park

Grand Canyon NP is the most biologically diverse park in the network, and is only slightly smaller than GLCA. Currently, the park flora includes ca. 1,500 species (N. Brian pers. comm., based on Phillips et al. 1987, Ayers and others 1995, Brian and others 1999). Preliminary vegetation work and a map are available based on Warren et al. (1982). Other recent contributions include Ayers et al. (1994), which documents 35 additions to the flora of GRCA (both native and non-native, including one listed as a noxious weed and being monitored for potential colonization downstream). A list of special status plant species documented in the Grand Canyon National Park Museum Collection is in Grand Canyon National Park (1993). Hodgson (1992, 1993, 1994a, 1994b) added over 250 specimens to the Grand Canyon park herbarium and the Phoenix Desert Botanical Garden Herbarium. Some collections are the result of studies in specific sections of the park (Thunder River, Surprise Valley, and the Esplanade). Phillips et al. (1979) discusses the diversity of the flora in relation to the range of habitats available, from hot desert scrub to subalpine forest. This work adds information on abundance, threatened or endangered status, and habitat type. Aitchison and others (1974) investigated flora of the riparian areas of the park, noting major vegetational communities of the Grand Canyon. The report also discusses vegetative changes resulting from controlled water release from the Glen Canyon Dam, and includes identification, distribution and relative abundance of plant species. A similar report is Bain (1976). McDougall (1947) provides an early checklist based on herbarium specimens. An NRBIB record describing the park's herbarium notes about 5000 items in 1969, with numbers similar in 1995, according to park staff. Some park botanical material is located at the herbarium at Northern Arizona University.

There are numerous regionally rare as well as one listed plant species, *Astragalus cremnophylax*, which is being monitored by park staff (Rowlands and Brian 1996). Seven additional species of special concern include *Arctomecon californica*, *Argemone arizonica*, *Camissonia specuicola* ssp. *hesperia*, *C. s.* ssp. *specuicola*, *Rosa stellata* ssp. *abyssa*, *Silene rectiramea*, and *Talinum validulum*.

Hubbell Trading Post National Historic Site

Hubbell Trading Post is a relatively small park unit at 65 ha. Baseline vegetation and floristic work covering certain vegetation types within the park has been done, but is not complete (Gandhi and Hatch 1987). Gandhi and Hatch (1987) includes a checklist of over 130 taxa, along with information on the nativity of the plants (native, or introduced but naturalized).

Mesa Verde National Park

A vegetation map (Floyd-Hanna 1992), and an old checklist of the flora (Welsh and Erdman 1964) are available. A Mesa Verde plant list provided by park staff in June 2000 is based almost exclusively on voucher specimens. Listed species are primarily those found in the park's own herbarium, however; the list isn't considered complete since it does not reflect most of the specimens housed at the herbarium at the University of Colorado, Boulder. The flora is relatively complete, but the park requires additional information on the status and distribution of nine special status species, including *Aquilegia micrantha var. mancosana, Astragalus deterior, Astragalus humillimus, Astragalus schmolliae, Collomia tinctoria, Hackelia gracilenta, Iliamna grandiflora, Penstemon parviflorus, Primula specuicola, Sclerocactus mesae-verdae, Spiranthes diluvialis.*

Numerous reports by MEVE staff member Marilyn Colyer include a species list (Colyer 1982), an annotated checklist (Colyer no date), and coverage of special status plants (Colyer 1991, 1994). Among her many field journals are two describing the collection of plant specimens (together in Colyer 1985). Fire reports and succession studies are prominent in NRBIB records concerning the vegetation of MEVE; these will have particular relevance to the fire losses at the park during the summer of 2000. Specialized information includes reports describing work on the cacti of the park by Alberding (1934, 1935). Wagner (1994 and prior reports from 1978-1987) concerns effects of Black Stain Root Disease on pinyon pines (*Pinus edulis*) in the park, and monitoring was continuing at three-year intervals. A few early superintendent reports contain botanical information, and more is found in reports by park naturalists (annual reports, 1930-1951). A thesis (Bader 1932) provides some early information on the life zones of the park and species associated with each.

Navajo National Monument

This monument consists of three isolated units: Betatakin (65 ha), Keet Seel (65 ha), and Inscription House (16 ha). Floristic and vegetation work has been conducted since the 1930's in Betatakin Canyon. Checklists along with information on plant communities, microhabitat relationships, and populations dynamics are found in "Ecological Studies at Navajo NM, Part I, II, and III," Brotherson and others (1977, 1980, and 1981), and a plant checklist in Brotherson and others (1978). In addition, more specialized studies by Brotherson and others (1980a, 1980b) focus on spatial patterns of plant communities, and on population dynamics and age relationships of eight tree species at the Monument. Other checklists and an overview of natural resources and processes at Betatakin Canyon are in Woodbury (1963). Information on population characteristics and habitat relationships of trees and shrubs appears in Brotherson et al. (1983), Fairchild and Brotherson (1980), and Schulman (1948). Brotherson et al. (1985) and Robinson (1986) describe the distribution and microhabitat characteristics of plant communities. The flora of the Keet Seel and Inscription House units is not well known. Information on the abundance and distribution of exotic species is lacking in all three units.

Several current papers, however, do add to knowledge of specialized areas: Drost (2000) on special status species, and Hudson et al. (2000) on the alcove bog orchid (*Platanthera zothecina*). Holiday (1998) surveyed the flora of the Tsegi Canyon drainage (including the Betatakin and Keet Seel units, but not Inscription House). A park herbarium, with specimens collected mainly in the 1930's and 1960's, contains over 500 specimens. The 500 plants listed by Wetherill (1937) were housed at Kayenta at the time, but are presumably part of the current park collection.

Petrified Forest National Park

PEFO is a medium-sized park with extensive semi-arid grasslands. In all, 17 vegetation types are documented for the park. Plant lists have been compiled over the years at Petrified Forest National Park (1966, 1976, 1981). Until recently, the thesis by Kierstead (1981) provided the best list for the park, along with a key for the identification of plants found at Petrified Forest NP and a reference collection of plant specimens. A vegetation survey being conducted by Hansen et al. (2000) includes systematic field work, vegetation characteristic analysis, and will include an updated plant list based on field studies and collections at the Deaver Herbarium at Northern Arizona University and Petrified Forest NP Herbarium. Information on exotic species is deficient, but not considered a priority.

Petroglyph National Monument

A survey of the biological resources of Petroglyph National Monument listed 192 plant species found during an August 1994 survey. Specimens from the survey are housed at the Museum of Southwestern Biology at the University of New Mexico. However, this survey was not complete for inventory purposes. Information is particularly lacking on the annual flora. An unpublished report (Barlow-Irick 1993) documents threatened and endangered species. A vegetation map is available, and nine vegetation types have been documented.

Rainbow Bridge National Monument

Basic floristic information at RABR is relatively complete. Currently, ca. 100 species are known from RABR, which is estimated to be ca. 90% of the expected flora. Some species on the list may pre-date the construction of Glen Canyon Dam and may have been eliminated by the rising waters of Lake Powell. For example, *Imperata brevifolia* was known in Bridge Canyon only from the drowned section.

Salinas Pueblo Missions National Monument

Floristic and vegetation work has been largely completed at SAPU (NPS unpublished data, Floyd-Hanna et al. 1994). Vegetation surveys, including plant specimen collections, were conducted in 1992-93 at the Abo and Quarai Units of Salinas Pueblo Missions NM. Initial assessment shows 12 plant communities within the Abo Unit and the Quarai Units. Some of the vegetation types for the Abo Unit consists of pinyon-juniper woodlands, salix-cottonwood riparian, oak brush, and tamarisk stands. Efforts to control tamarisk found both inside and outside the Abo Unit have been made. The Quarai Unit has a perennial water source that supports a more diverse community than the Abo Unit. Four possible riparian communities are cottonwood-willow, typha wetland, rose-horsetails, and pseudoriparian meadows. The Quarai uplands consist of pinyon-juniper-berberis woodlands, oak pinyon woodlands, open, early successional pinyon woodland, ponderosa pine stand, sagebrush-horsebrush stands, and various disturbed meadows and apple orchards remnant of historic occupation. Color infrared aerial and black-and-white photographs have been transferred into a geographic information system and some plant specimens are located at San Juan College. Currently, there are no known special status or listed plant species. A vegetation map also has been completed (Floyd-Hanna et al. 1994).

Sunset Crater National Monument

Most of the vegetation studies in this area have focused on both Sunset Crater Volcano and Wupatki National Monuments. A Museum of Northern Arizona bulletin (McDougall 1962) lists plant species, and includes a key for the identification of the species known from the two monuments. Additions and deletions were made to the 1962 list based upon further examination of plant collections at Sunset Crater Volcano and Wupatki Nation Monuments, the Museum of Northern Arizona, and the Deaver Herbarium at Northern Arizona University by Rominger (1976). Vegetation studies were conducted at Sunset Crater and Wupatki National Monuments by staff and students from Northern Arizona University, and are detailed in a series of reports that include information on plants (Bateman 1976, 1980). Vegetation and grazing studies at both Monuments were mainly limited to grazing enclosures, however, and were limited

in intensity and geographic coverage. Nonetheless, data from these studies do provide some potentially useful comparative information for the species that were documented. A USGS/NPS park mapping sponsored vegetation map is in progress. Only four vegetation types have been documented for the monument. The distribution and abundance of rare species has also been studied (these include *Penstemon clutei*, *Phacelia serrata*, *Phacelia welshii*).

Walnut Canyon National Monument

WACA has completed basic floristic inventories (Brian 1985, Jenkins and others 1991). Most of inventory work at Walnut Canyon has focused on the flora of the area, including a study (Despain and Mosley 1990) that examined the historical role of fire and its effects within a pinyon-juniper woodland at Walnut Canyon NM. A listing of plant species is available based on a thesis (Joyce 1974, reprinted as a 1998 park checklist) which also includes the work from previous studies (Arnberger 1947 and Spangle 1953). A USGS/NPS park mapping sponsored vegetation map is in progress. Nine vegetation types have been documented in the Monument. Basic surveys for rare plants have been completed (including Arizona bugbane, *Cimicifuga arizonica*, Arizona leatherflower, *Clematis hirsutissima arizonica*, Arizona walnut, *Juglans major*, cliffrose, *Cowania subintegra,* Flagstaff Pennyroyal, *Hedeoma diffusum*, and fleabane, *Erigeron saxatilis*).

Wupatki National Monument

As noted above a series of vegetation studies were conducted at Sunset Crater and Wupatki National Monuments by McDougall (1962) and Bateman (1976, 1978, 1980, 1981). Most of these studies were conducted at both Monuments, but an additional survey of range condition trends on Wupatki National Monument was conducted in 1981. A USGS/NPS park mapping program vegetation map is in progress. Twenty SRFR vegetation types have been documented. Information on the status and distribution of eleven rare species is deficient. These species include Ditch evening primrose (*Camissonia specuicola hesperia*), Fickeisen pincushion cactus (*Pediocactus peeblesianus fickeiseniae*), Freckled milkvetch (*Astragalus lentiginosus ambiguus*), Peebles' Blue Star (*Amsonia peeblesii*), Parish alkali grass (*Puccinellia parishii*), Roundleaf errazurizia (*Errazurizia rotundata*), Simpson plains cactus (*Pediocactus simpsonii*), Water parsnip (*Cymopterus megacephalus*), Welsh Phacelia (*Phacelia welshii*), and Whiting indigobush (*Psorothamnus thompsoniae whitingii*).

Yucca House National Monument

At 14 ha, this is the smallest NPS unit in the network. Due to the primary charge of protection and research of cultural resources of Yucca House NM, natural resource management has been limited. A flora survey compiled by Mesa Verde NP staff shows the dominant shrub is greasewood (*Sarcobatus vermiculatus*), and 85% of the dominant understory is nonnative cheatgrass. A plant list for the Monument, which is surrounded by agriculture lands, lists 67 plant species. This list was updated in February 2000, based on surveys and field notes from Mesa Verde park staff and outside specialists and other agencies including the Colorado Division of Wildlife (George San Miguel, MEVE Resources Management Division, pers. comm.). A vegetation map has been completed, and includes 11 habitat types (Colyer 1989). Two rare species of concern – *Centaurium exaltatum* and *Echinocereus fendleri* – occur in the park, but information on their distribution and abundance is lacking. Information from MEVE also includes *Sclerocactus mesae-verdae* as possible in YUHO, with G2,S2 rankings. There are 12 plant species and 14 plant slides documented for YUHO in the collections at Mesa Verde NP. This information is based solely on June through July 1985 surveys, and has not received critical review.

2.2 Summary of inventory completeness

2.2.1 Initial appraisal

We identified priority inventory needs for NPS units on the Southern Colorado Plateau based on the information presented above (see *Existing information*) and preliminary estimates of inventory completeness (Table 2). These estimates were modified during group discussions held at a workshop in Moab, UT, in May 2000, in light of additional considerations primarily related to on-going work that did not factor into preliminary estimates or outdated existing lists. Researchers and NPS managers familiar with the biological resources and previous inventory work in each unit were responsible for making initial estimates. Although we accounted for on-going and previous inventory work, only rarely were lists of the species expected in and documented for each unit available for us to consult at this early stage. Even so, a cursory appraisal was adequate to identify numerous units with obviously deficient information (Table 2). The needs of these units required most of the funds currently allocated for inventory work on the southern Colorado Plateau (see below under **Budget**).

Table 2. Initial estimates of percent completeness of species lists, by taxonomic group, for NPS units on the Southern Colorado Plateau. Medium gray denotes groups and NPS units judged to be in greatest need of basic inventories; light gray denotes groups and units judged to be in next greatest need (see Table 3).

Park	*Taxonomic group*			
	Birds	*Mammals*	*Amph. & Reptiles*	*Plants*
AZRU	**0**	**0**	**0**	**0**
BAND	>90	**80**	**50**	90
CACH	60	90	**70**	**60**
CHCU	98	**80**	**80**	90
ELMA	75	80	80	**80**
ELMO	**80**	85	**70**	**85**
GLCA	95	70	**70**	**80**
RABR	95	80	80	95
GRCA	90	90	90	>90
HUTR	**0**	**0**	**0**	**40**
MEVE	95	75	80	90
NAVA	85	**25**	**50**	**85**
PEFO	90	90	80	90
PETR	**70**	**70**	**70**	**70**
SAPU	**30**	**?**	**30**	90
SUCR	90	75	**70**	90
WACA	80	**70**	**30**	90
WUPA	85	**85**	75	90
YUHO	**80**	**75**	**50**	**80**

Because almost all currently available funds are obligated to cover the needs of NPS units with obviously deficient inventory information, we deferred more rigorous evaluation of initial estimates of inventory completeness for other units until after submission of this proposal. If any more inventory needs are identified during this second round of appraisals, we will pursue additional funding from other programs or from the Inventory and Monitoring Program at a later date.

2.2.2 Appraisal of completeness in NPS units not scheduled for basic inventories

We will appraise current estimates of inventory completeness for NPS units not scheduled for basic inventories in several ways. Options for appraisal are limited by the nature of existing species lists. Most are based on *ad hoc* collections or observations. Even where substantiated by or based on designed studies, raw data from these investigations are only rarely available. For these reasons, we cannot reliably use the various model-based methods based on rarefaction or mark-recapture to estimate completeness (i.e., "coverage") (Bunge and Fitzpatrick 1993, Boulinier et al. 1998).

Our primary approach to appraising existing estimates of inventory completeness will be based on master lists compiled by taxonomic-group experts. This approach entails, first, compiling lists and associated documentation for species known to occur in each NPS unit. Next, experts compile lists of species expected to occur in each unit based on features of the park and known habitat relations and distributional ranges of regional species. The first list is compared to the second, and the percent discrepancy provides some indication of inventory completeness. Individual species also can be identified that are on both lists, or exclusive to one or the other. This facilitates recognition of misidentified species on existing lists.

We plan a modified approach that will impart additional information to this conventional comparison. Based on associated documentation, we plan to score each species on existing lists for each unit as either possibly occurring (= 1), probably occurring (= 2), or certainly occurring (= 3). We will use the same scoring for the list of expected species compiled by experts, but in this case based on information about habitat relations, distribution, and rareness. The comparison (percent coverage, *PC*) will then be based on weighting each observed (*obs*) and expected (*exp*) species (*i*) by its score (*Sc*):

$$PC = (\sum Sc_{obs,\,i}) / (\sum Sc_{exp,\,i}).$$

This approach retains information about uncertainty in lists of both observed and expected species and reduces the number of categorical decisions regarding absolute presence or absence – decisions potentially subject to vagarious standards.

Model-based methods will be used to estimate species richness using data obtained from field studies planned under terms of this proposal (see below under **Sampling design considerations, *Estimating species richness***). We plan to use area-adjusted estimates of species richness from these field studies as an additional check against richness estimates in other units with similar ecological conditions. We will adjust for the area of park units first by increasing or decreasing the intercept of the taxonomically-appropriate species-area equation proportional to the discrepancy between the equation prediction and the data-based area-specific estimate of richness. We will then predict species richness for other units using the intercept-adjusted model and the area (in ha) of the park unit of interest.

3. Priorities for additional work

Table 3 lists NPS units and associated taxonomic groups in need of basic species inventories or other related field work. We assigned each planned inventory to priority 1 and priority 2 groups. Determination of priority was based on preliminary estimates of current inventory completeness, the existence of pressing management issues, the availability of additional funds, and the likely products of on-going work. Deference also was given to smaller park units. This was done for two reasons: (1) because of the general paucity of biological information from small compared to large parks on the southern Colorado Plateau, and (2) because of the greater surety of completing work in smaller park units using available resources. Details for the selection of units for inventory work are presented in the following sections.

NPS units planned for basic inventories (noted by "BI" in Table 2) are also scheduled for other work focused on species of special concern. In the case of birds, this will entail methods designed specifically to detect Golden Eagles, Southwestern Willow Flycatchers, and Spotted Owls (see below under **Field Methods, Birds**). For plants, this includes focused surveys of habitats likely to contain special status or exotic species (see below under **Field Methods, Plants**). Some NPS units are scheduled only for surveys of special status and/or exotic plant species, denoted by "SS" and "ES," respectively in Table 2.

Table 3. NPS units on the Southern Colorado Plateau identified as needing biological inventory, by taxonomic group and distinguishing first from second priority inventories. Units needing a basic inventory are denoted by "BI," those needing surveys of special status species by "SS," and those needing surveys of exotic species by "ES." NPS units are identified by planning clusters, which were developed on the basis of geographic nearness and common inventory needs of the same priority (see Fig. 1). All inventory work for a given taxonomic group within a given planning cluster is treated as a single project.

Park	***Planning cluster***	***First priority***				***Second priority***			
		Birds	*Mammals*	*Amph. & Reptiles*	*Plants*	*Birds*	*Mammals*	*Amph. & Reptiles*	*Plants*
AZRU	1	BI	BI	BI	BI				
YUHO	1	BI	BI (Bats)	BI	BI				
CACH	2	BI		BI	BI				
HUTR	2	BI	BI	BI	BI				
NAVA	2		BI	BI	ES				
ELMO	3	BI		BI	BI				
PETR	3	BI	BI	BI	BI				
SAPU	3	BI	BI	BI					
WUPA	4		BI (small mammals)	BI					SS
SUCR	4			BI					
WACA	4		BI (small mammals)	BI					
BAND	5						BI (sm. mammals)	BI	SS
CHCU	5						BI (sm. mammals)	BI	SS, ES
ELMA	6					BI	BI		
GLCA	7							BI	BI
RABR	7								
GRCA	8								SS,ES
MEVE	9								SS
PEFO	10								

Field work is planned in all parts of units designated for inventories or other surveys, with the following exceptions. For Petroglyph NM (PETR), inventories of all four taxonomic groups are planned only in a recent 890 ha addition to the unit. A basic plant inventory is planned on only ca. 121,200 of the total 507,618 ha in Glen Canyon NRA (GLCA).

3.1 Birds

3.1.1 Planning clusters 1-3 (First Priority) Species Field Inventories

The following units in Clusters 1-3 have very little or no information available on bird species that occur within each park unit: Cluster 1 – AZRU, YUHO; Cluster 2 – CACH, Cluster 3 - ELMO, PETR, SAPU; Cluster 6 – ELMA. Species presence/absence has not been adequately determined for these park units. Lacking such baseline information, the park units cannot develop management policies for the avian fauna. Likewise, they lack data on the occurrence of rare or sensitive species. These units have the highest priority needs for avian fauna inventories.

3.1.2 Planning cluster 5 (Second Priority) Species Field Inventories

The only remaining unit is in Cluster 5 – ELMA. This park unit has limited information available on avian species presence/absence, but due to its size and limited scope of previous research and funding, this park will benefit from additional surveys. The poor state of knowledge of the avian fauna of this park, particularly the status of rare and sensitive species, limits the ability of the park units to make informed management decisions.

3.1.3 Parks with Species of Special Concern

Many of the park units have bird species of special concern. These species may be federally listed as either threatened or endangered, or listed as a state sensitive species that the park resides in. Additional information on status and distribution is needed; therefore, priorities have been established depending on the status of the species and availability of funding, as determined by a panel of experts at the Moab meeting. The following species are listed according to priority needs:

- Priority 1 - Southwestern Willow Flycatcher (*Empidonax traillii extimus*) – MEVE, BAND, PEFO;
- Priority 2 - Burrowing Owl (*Athene cunicularia*) – ELMA, WUPA;
- Priority 3 - Northern Goshawk *(Accipiter gentilis)* – MEVE, WUPA, SUCR, WACA; and,
- Priority 3 - Golden Eagle – AZRU, BAND, CACH, CHCU ELMA, ELMO, GLCA, GRCA, HUTR, MEVE, NAVA, PEFO, PETR, RABR, SAPU, SUCR, WACA, WUPA, YUHO.

3.2 Mammals

3.2.1. Planning clusters 1-3, Baseline Inventories

Several parks in the SCP need partial or full baseline inventories, as discussed at the inventory planning meeting in Moab in May. In general, little information on species occurrence or abundance for mammals is available for parks in Clusters 1-3, although some efforts are underway on selected parks. AZRU needs a full baseline survey as no information is available, and YUHO needs bat surveys to complement other mammal work overseen by MEVE. A cooperative agreement has been signed with USGS to provide these surveys during FY01-02 and no additional request is made in this proposal. Three additional parks (CACH, HUTR, NAVA) are tribal parks, and information on mammals at these parks is limited. Full baseline inventories are needed and will require coordination with the Navajo Nation and the Navajo Fish and Wildlife Service. Finally, there are three parks in New Mexico that need work: ELMO and SAPU need full inventories; and PETR needs some selected work on the original park, as earlier surveys were spotty, and needs full inventories on the recent addition to the park.

3.2.2. Planning cluster 4, Baseline inventories

The three parks in this cluster (SUCR, WACA, WUPA) are collectively referred to as the Flagstaff Area Parks. They have received preliminary study, but are still deficient for mammal inventory, particularly for small mammals (rodents, shrews, bats). Some baseline natural resource surveys are currently being conducted by USGS as part of the Flagstaff Area Parks' 'Visitor Experience and Resource Protection' (VERP) project, which is developing inventory methods for assessing park visitation levels in relation to effects on park natural and cultural resources. Small mammal surveys for SUCR (as well as some monitoring-related studies on large mammals at all three areas) will be completed as part of the VERP effort, so mammal inventory efforts as part of the current proposal will be focused on small mammals at WACA and WUPA.

3.2.3. Planning clusters 5-6, Focused inventories

Three parks (BAND, CHCU, and ELMA) have varying levels of previous work on mammals. Work on bats at BAND was conducted from 1995-98 by USGS, but information on most other mammals is old or of limited usefulness and scope; little of the backcountry of BAND has been inventoried. Bat inventories are currently being conducted by USGS at CHCU and ELMA and will be finished this year, but work is needed on other groups at these parks. Both parks have had only very limited rodent surveys.

3.2.4. Inventories of species of concern

Some parks would benefit from inventories for selected species of concern or poorly known, peripheral species (see Project Statement for this work).

3.3 Amphibians and Reptiles

3.3.1 Planning clusters 1-4 (First Priority) Species Field Inventories

The following units in Clusters 1-4 have little or no information available on the reptile and amphibian species that occur within them: AZRU, CACH, ELMO, HUTR, NAVA, PETR, SAPU, SUCR, WACA, WUPA, and YUHO. Species presence/absence has not been adequately determined for most of these smaller parks. With such a lack of baseline information, the park units have no ability to develop management policies for the herpetofauna, and also no knowledge of the occurrence of rare or sensitive species. These park units have the highest priority needs for herpetofauna inventories.

3.3.2 Planning clusters 5-6 (Second Priority) Species Field Inventories

The remaining park units in Clusters 5 and 6 (BAND, CHCU, ELMA, GLCA, RABR) have some limited information available on species presence/absence, but due to their size and/or limited scope of previous research, will benefit from additional surveys. The poor state of knowledge of the herpetofauna of these units, particularly the status of sensitive species, presently limits the ability of the park units to make informed management decisions.

3.3.3 Parks with species of special concern

See Appendix C. Many parks have species of special concern for which additional information on status and distribution is needed, but for which no funding is requested at this time.

3.4 Vascular plants

Some park units are most in need of comprehensive inventories of vascular plants. These include AZRU and YUHO (Cluster 1), HUTR and CACH(Cluster 2), ELMO and PETR (Cluster 3), and CHCU (Cluster 5). GLCA is the only large park unit needing general surveys of the flora, and these will be concentrated

in areas of GLCA that are poorly known. Other park units in the southern Colorado Plateau have priority needs for targeted surveys of particular groups of plants. These surveys will target either special status species (designated threatened, rare, or other native species that are of concern because of their rarity or vulnerability) and non-native ("exotic") species that are of concern because of their potential to invade native habitats. Areas with priority needs for both special status / rare species survey, and survey for non-native species, include NAVA (Cluster 2), WUPA (Cluster 4), CHCU (Cluster 5), and GRCA (Cluster 8). In addition, BAND (Cluster 5) and MEVE (Cluster 9) both need targeted surveys for special status species. Project statements can be found in Section 6.

3.4.1 Planning Clusters 1-3 (First Priority) Species Field Inventories.

Six parks that need basic floristic inventories are AZRU, CACH, ELMO, HUTR, PETR, and YUHO. Total projected costs are $50,000. Two projects are needed, one for the three parks on the Navajo Nation (CACH, HUTR, NAVA), and one for the parks in the east (AZRU, PETR, YUHO).

3.4.2 Planning Clusters 6-7 (Second Priority) Species Field Inventories.

GLCA requires additional species inventory work.

3.4.3 Planning Clusters 4, 5, 8 and 9, Species of Special Concern Inventories.

Five parks require status and distribution information on special status native species, BAND, CHCU, MEVE, GRCA, and WUPA.

3.4.4 Planning Clusters 4, 5 and 8, Exotic Species Inventories.

Three parks require surveys on the abundance and distribution of exotic species, CHCU, GRCA and WUPA. These can be combined with 3.4.3 for CHCU and WUPA.

4. Methods

The Southern Colorado Plateau Network park units worked together to develop this inventory proposal, with each unit designating a representative from its staff. Table 4 lists resource management contacts for each of the NPS units in the network. Representatives worked together at two workshops to scope and set priorities for the inventory proposal. Dr. Ron Hiebert, Research Coordinator at the CESU at Northern Arizona University, assisted the network in the process, and oversaw review of literature for inventory information, and compilation of existing inventory data for the network park units. The NPS Intermountain Region I&M Coordinator also participated, and remains a primary contact at the regional and directorate level.

Table 4. List of resource management contacts for each of the NPS units in the Southern Colorado Plateau Network.

Park unit	*Contact*	*Contact Info*
AZRU	Theresa Nichols	P. O. Box 640 Aztec, NM 87410
BAND	Brian Jacobs	HCR 1, Box 1, Suite 15 Los Alamos, NM 87544
CACH	Tom Workman	P. O. Box 588 Chinle, AZ 86503
CHCU	(currently vacant)	P. O. Box 220 Nageezi, NM 87037
ELMA	Herschel Schultz	P. O. Box 939 Grants, NM 87020
ELMO	Brian Quigley	Route 2, Box 43 Ramah, NM 87321-9603
GLCA	John Spence	P. O. Box 1507 Page, AZ 86040-1507
GRCA	Jerome Montague	P. O. Box 129 Grand Canyon, AZ 86023
HUTR	Mary Furney	P. O. Box 150 Ganado, AZ 86505
MEVE	George San Miguel	P. O. Box 8 Mesa Verde NP, CO 81330-0008
NAVA	Laura Hudson	12795 West Alameda Parkway Lakewood, CO 80228
PEFO	Karen Beppler	P. O. Box 2217 Petrified Forest, AZ 86028
PETR	Mike Medrano	6001 Unser Blvd NW Albuquerque, NM 87120
SAPU	Loretta Moseley	P. O. Box 517 Mountainair, NM 87036
SUCR	Paul Whitefield	6400 N. Hwy 89 Flagstaff, AZ 86004
WACA	Paul Whitefield	same as above
WUPA	Paul Whitefield	same as above
YUHO	George San Miguel	P. O. Box 8 Mesa Verde NP, CO 81330-0008

A Science Advisory Panel was established by having the park representatives nominate and vote on academic and agency scientists who have active research programs at the parks or surrounding region, and who have established expertise in one of the five taxonomic groups and in current inventory and monitoring methods. This panel has provided the necessary scientific oversight for the process, including help in the scoping workshops and in writing the study plan. The Science Advisory Panel includes faculty from area universities and agency biologists from the USGS Field Stations at the University of New Mexico, Northern Arizona University, and Jemez Mountains. The advisory panel was involved in planning workshops, and worked together to write the proposal. Other cooperators on the southern Colorado Plateau, or that have expertise in the region, will be identified to collaborate with the network as the inventory project progresses. This will include other agency personnel that can provide review of the study plan or who may be involved in inventory work following acceptance of the plan.

A study design workshop was held on 22-25 May 2000 to review priorities for inventory studies within the SCP Network, select field methods for inventory, discuss data analysis techniques, assign writing tasks for this proposal, and develop preliminary budgets. Preliminary schedules for field inventories were also discussed. Funds were allocated for an editor for the inventory proposal, to ensure that all of the information from a variety of sources is synthesized into a single document, and that the inventory plan receives appropriate review and revision before the due date. There was also discussion of long-term goals and monitoring plans during the course of the meeting.

The remainder of this Methods section discusses sampling design (including selection and number of sampling points, and stratification), proposed methods for estimating species richness (and achieving the 90% goal set forth by the Park Service I&M Office), and field methods for all of the vertebrate and vascular plants groups included in this inventory.

4.1 Sampling Design

The three primary tasks in developing a sample design for biological inventories are: (1) estimate the number of plots needed to achieve 90% completeness in each NPS unit; (2) spatially and temporally allocate these plots; and, (3) determine what methods will be used to gather data at sampled points, specific to each taxonomic group. Although these three tasks are somewhat inter-related (e.g., field methods affect sample intensity and sample distribution), each is treated in turn in the following sections.

4.1.1 Number of sample points

For planning purposes, we estimated the number of sample points required to achieve 90% completeness in each inventory based on the number of species estimated to be in an inventoried unit (S) and the number of species we expected to detect, on average, in a single plot (MS). We estimated S from species-area curves specific to each taxonomic group except plants. We estimated MS from the results of field studies and our personal experience. Number of plots was estimated from the ratio of MS to S, assuming a natural-log (for vertebrates) or square root (for plants) decay in the rate of species detection with the additional sample points.

Species-area models relate S to the natural-log transformed area of an inventoried unit (A), reckoned here in hectares (ha). We used the following models for vertebrates:

Birds:	$S = 28.7 + 6.43*\ln(A + 1)$	$n = 35$, $R^2 = 0.70$
Mammals:	$S = 7.42 + 3.82*\ln(A + 1)$	$n = 34$, $R^2 = 0.74$
Reptiles:	$S = 6.86 + 1.64*\ln(A + 1)$	$n = 19$, $R^2 = 0.69$

We tested for, and did not find, evidence of effects of habitat diversity in the equations for mammals and reptiles. This result accords with Newmark (1986) and previous observations that habitat diversity is often highly correlated with area. We also used analysis-of-covariance to control for the effect of different data sets. Where there was such an effect, we used the intercept that we deemed most applicable to the southern Colorado Plateau. We used data from Newmark (1986), Boecklen (1997), and Drost et al. (1998) for mammals; from Kratter (1992), Boecklen (1997), and Drost et al. (1998) for birds; and from Jones et al. (1985), Boecklen (1997), and Drost et al. (1998) for reptiles. Although other researchers (e.g., Flather 1996) have developed species-area curves for these taxonomic groups, most are applicable at different scales or to different regional ecological conditions.

A different relationship holds for plant species on the Colorado Plateau. Both area and habitat diversity (measured simply as elevational relief in meters) are important predictors of species richness. Based on data for parks with 90% complete plant lists, the best predictive equation is:

$$\text{Plants:} \quad S = 182.9 + 41.7(\ln[Area+1])*Elevation \qquad n = 12,\ R^2 = 0.89$$

Elevation is defined as the difference in meters between the maximum and minimum elevations in a park. Of the two factors, elevation is the best single predictor of species richness. The number of expected species of plants for each park in Table 5 is based on this equation.

We used the preceding models to predict *S* for each taxonomic group for each NPS unit in the southern Colorado Plateau (Table 5). We used these estimates for planning purposes only. Where inventories are conducted, we will determine the number of points ultimately sampled from on-going appraisals of completeness derived from iterative estimates of species richness (see below under ***Estimating species richness***).

We estimated number of species detected at the first inventory plot (*SM*) from published results for mammals and birds and from inventory experience of the authors for amphibians and reptiles. For small non-volant mammals, *SM* averaged 3.9. The standard deviation and range were remarkably small (1.3 and 3.6, respectively) for five studies that we reviewed (Mitchell et al. 1995, Sullivan et al. 1998, 1999, Kelt 1999, Kelt et al. 1999). Based on our best judgement, we doubled this figure to 8 for all mammals (large and small, volant and non-volant). For birds, *SM* averaged 12.8, but only after accounting for the effects of plot size and number of visits, standardizing plots to 1 ha and visits to 3 times ($n = 9$; Avery and van Riper 1989, McGarigal and McComb 1992, Hutto 1995, Hawrot and Niemi 1996, Baker and Lacki 1997, MacNally 1997, Easton and Martin 1998, Kilgo et al. 1998, Schulte and Niemi 1998). Based on professional judgement, *SM* was estimated to be 4 and 30 for reptiles and vascular plants, respectively.

We estimated the number of sample points (*nsp*) required to detect 90% of expected vertebrate species by assuming that the natural-log decay in detection of new species with addition of plots was defined by *SM* (richness at the first plot in a sequence) and *S* (the culmination or asymptote). We expressed this as the ratio:

$$\ln(nsp + 1) / 0.693 = (S * 0.9) / SM, \text{ where } 0.693 = \ln(1 + 1).$$

$$\text{By solution, } \ln(nsp + 1) = (S * 0.624) / SM.$$

Number of samples (*nsp*) was then obtained by raising the resultant to *e* and subtracting 1 (Table 5). This equation produces reasonable results for the range of *S* considered for vertebrates: 10–120 species. At greater values of *S*, typical of plants species in most parks, estimates of *nsp* are much too large. For plants, the assumption of square root decay in detection of new species produced more reasonable results. For reasons explained below (see **Spatial arrangement**), we also estimated number of sample points based on a requirement of 70% rather than 90% completeness. For plants this yielded the equation:

$$(nsp + 0.5)^{0.5} = (S * 0.858) / SM.$$

Table 5. Expected number of species in NPS units of the Southern Colorado Plateau and estimated number of sample points to detect 90% of the expected species, by taxonomic group. Expected number of species is based on the area of each unit; number of sample points is estimated based on expected total number of species and expected average number of species detected per sample point, assuming a natural log or square root relation or between number of detected species and number of sample points (see text for details).

Park	*Area (ha)*	*Expected number of species*				*Approximate number of sample points in 2 yrs to detect 90% of expected species*			
		Birds	*Mammals*	*Amph./ Reptiles*	*Plants*	*Birds*	*Mammals*	*Amph./ Reptiles*	*Plants*
AZRU	130	**60**	**26**	**15**		***18***	***7***	***10***	
BAND	13825	**90**	**44**	**22**	**774**	***79***	***32***	***35***	***(490)***
CACH	33929	**96**	**47**	**24**		***105***	***43***	***45***	
CHCU	13749	**90**	**44**	**22**	**289**	***79***	***32***	***35***	***(68)***
ELMA	46479	**98**	**48**	**24**	**456**	***116***	***47***	***49***	***(170)***
ELMO	518	**69**	**31**	**17**	**202**	***28***	***11***	***14***	***(33)***
GLCA	507618	**113**	**58**	**28**	**917**	***246***	***99***	***92***	***(688)***
RABR	65	**56**	**23**	**14**	**186**	***14***	***6***	***8***	***(28)***
GRCA	488616	**113**	**57**	**28**	**1481**	***243***	***98***	***91***	***(1794)***
HUTR	65	**56**	**23**	**14**	**186**	***14***	***6***	***8***	***(28)***
MEVE	21079	**93**	**45**	**23**	**498**	***90***	***37***	***40***	***(203)***
NAVA	146	**61**	**26**	**15**	**323**	***18***	***7***	***10***	***(85)***
PEFO	37852	**96**	**48**	**24**	**341**	***109***	***44***	***46***	***(95)***
PETR	2932	**80**	**38**	**20**	**276**	***48***	***20***	***23***	***(62)***
SAPU	433	**68**	**31**	**17**		***26***	***11***	***14***	
SUCR	1230	**74**	**35**	**18**	**294**	***37***	***15***	***18***	***(71)***
WACA	1433	**75**	**35**	**19**	**252**	***38***	***16***	***19***	***(52)***
WUPA	14291	**90**	**44**	**23**	**358**	***80***	***33***	***36***	***(105)***
YUHO	14	**46**	**18**	**11**	**187**	***8***	***3***	***5***	***(29)***

Results are given in parentheses in Table 5. Because we did not have as much confidence in our estimate of *nsp* for plants, number of sample points and related cost estimates for each plant-related project and NPS unit are based on the expert judgment of botanists with experience sampling vegetation on the Colorado Plateau. The figures in Table 5 provided confirmation of these judgements and provide a point of reference. As with other taxonomic groups, initial densities of sample points will be revised in light of estimated completeness of inventories after each successive year of fieldwork. Because of less systematic methods, the basis for changing sample point densities will be more subjective (see ***Temporal arrangement*** below).

We resorted to this approach to estimating *nsp* because of the paucity of relevant published work, especially in terms generalizable to different *S* and *A*. In general, the estimates of *nsp* agree with our professional judgment. The estimates also are in general agreement with other research on effort to achieve 90% inventories. For example, Neave et al. (1997) recommend 150–200 plots to detect ca. 85% of 173 avian species in ca. 3,000,000 ha – similar to the 240–250 plots that we recommend to detect the 113 or so avian species expected in either Grand Canyon NP (GRCA) or Glen Canyon NRA (GLCA); or the 18 sample nights recommended by Moreno and Halffter (2000) to detect 20 species of bats – similar

to the 18 sample points that we recommend for detecting 90% of the predicted 26 mammal species in Aztec Ruins NM (AZRU).

4.1.2 Stratification

Stratification here generally refers to the framework for planning sampling or organizing biological information. Stratification can be attentive to heterogeneity in logistics, such as cost of sampling, or to heterogeneity in the biological response of interest – in this case species richness (Cochran 1977). With respect to sample design, we will apply stratification in the following way. Upon detailed examination of the sampling environment, principal investigators will decide whether stratification for logistical or biological reasons is appropriate to each inventoried NPS unit, and whether stratification will be by landform, hydrologic features, and/or some level of vegetation or geological classification. If stratification is deemed appropriate, strata will be registered to the sampling grid (see **Spatial arrangement** below). In other words, strata, however mapped, will be overlain on the sampling grid and grid cells will be classified wholly within one stratum or another based on where the cell centroid falls. The sample grid will permanently register the strata used for sampling. Sample density will be adjusted for different strata based on iterations of random selection described below.

We plan to use consistent descriptions of vegetation types and landforms, either to identify and map strata, classify sample points, or otherwise organize inventory information. All points will be classified in the field to vegetation type and landform, regardless of the stratum to which the cell was allocated by GIS analysis. For slope classification, we will use the system of Dalrymple et al. (1968). This taxonomy (i.e., interfluve, seepage slope, convex creep slope, fall face, transportational midslope, colluvial midslope, colluvial footslope, alluvial toeslope, channel wall, and channel slope, where fall face roughly equates to "cliff," with slope a minimum of 45°, but normally greater than 65°) is described in most introductory geomorphology textbooks. Where relevant, we will use the finest-resolution classes of the standard U.S. Geological Survey system on geological maps to describe geologic formations.

In order to be useful in inventory work, a vegetation classification needs to be hierarchical. Currently, only three vegetation classifications being used on the Colorado Plateau provide this structure: the National Vegetation Classification (NVC), the Brown-Lowe-Pase (BLP) classification (Brown 1982), and the SRFR vegetation classification (Spence et al. 1995, Spence 1997a). The SRFR is a modified BLP classification with some differences in hierarchical structure. There is also correspondence between the NVC and SRFR systems for some hierarchical levels. The Federal Geographic Data Committee (1977) has adopted the NVC to be used by all government agencies in order to facilitate uniform vegetation classifications and communication between agencies. An initial listing of alliance types accepted under the NVC has been developed and is available through the Association for Biodiversity. Additional refinement of alliance descriptions in the study area is being concurrently developed by the USGS National Gap Analysis Program and the USGS/NPS Park Mapping Program.

We will use available data for vegetation classification as part of the inventory process on the Colorado Plateau. The project coordinator will provide inventory teams with the most current classification key for the study area. This key will include NVC alliances where known and SFRF vegetation types where adequate NVC description does not yet exist. Field crews will assign a site a provisional vegetation type as well as collect quantitative data at each sampling location.

Field data should be collected using a standardized field protocol. This can be accomplished through the use of modifications of the CPVAC relevé data form (see below under **Field Methods**) and the USGS/NPS Park Mapping relevé field form. Once the species and associated data is collected, the NVC can be verified using existing verification protocols. The project coordinator will be responsible for determining the appropriate verification protocols through consultation with the NPS Inventory and Monitoring Program, the USGS/NPS Park Mapping Program, the Association for Biodiversity

Information and the ESA Panel on Vegetation Classification. These protocols are currently in development, so anticipation of the appropriate protocol will be premature. The SRFR classification and CPVAC data form can be found in Appendices D and E.

Because the vegetation classification systems are hierarchical, stratification for sampling flora and vertebrates can be done at any level, from the relatively broad formation (e.g., forest, shrubland, grassland;, through intermediate levels (e.g., evergreen forest, montane cold-deciduous shrubland, cold-temperate mixed short bunchgrass-sodgrass grassland), to floristic vegetation types. Examples of the hierarchical levels for both the SRFR and NVC can be found in Table 6.

Table 6. A comparison of the relationship between the SRFR vegetation classification and the Standardized National Vegetation Classification (SNVC). The example is for a closed canopy *Pinus ponderosa/Festuca arizonica* community.

SRFR CLASSIFICATION	EXAMPLE	SNVC CLASSIFICATION	EXAMPLE
Biogeographic Realm	Nearctic	-	-
Floristic Province	Colorado Plateau	-	-
Climate-Elevation Zone	Montane	-	-
-	-	Division	Vegetated
Formation	Forest	Order	Forest
-	-	Physiognomic Class	Closed Canopy
Physiognomic Class	Evergreen	Physiognomic Subclass	Evergreen
-	-	Physiognomic Group	Temperate/Subpolar Needle-leaved
-	-	Subgroup	Natural
-	-	Formation	Rounded Crowns
Alliance	*Pinus ponderosa*	Alliance	*Pinus ponderosa*
Association	*Pipo/Festuca arizonica*	Association	*Pipo/Festuca arizonica*

The use of a relevé to describe the vegetation at each sampling point will allow for direct comparisons between parks for not only floristic data, but vertebrate survey data as well. In addition, the use of a standard relevé size means that species-area curves can be calculated for floristic species richness estimates. We will do a preliminary analysis using relevé data from a park mapping project to look for species area relationships and to estimate numbers of sampling points necessary to capture 90% of plant species. Because of the value of doing vegetation description, we will require all inventory teams to record the vegetation type at each sampling point, using an alliance level key. These data will be sent to the project coordinator. The information will assist in producing a database of vegetation descriptions for the Colorado Plateau parks at the alliance level.

4.1.3 Spatial and temporal arrangement of sample points

4.1.3.1 Spatial arrangement

Sample points will be located relative to a digital grid overlain on maps of NPS units scheduled for inventory of some taxonomic group. Final location of the grid will be determined by selecting a random point within one-grid-cell distance of initial grid placement, and then moving the upper left-hand corner of the grid to this new point. Grid cells will be randomly chosen for sampling. The points actually sampled will be located at the centroid of chosen grid cells. This approach provides the combined benefits of good coverage (grid spacing of points) and randomization (location of grid starting point and selection of grid cells) (Cochran 1977, Stevens 1997).

Grid density for each NPS unit will be determined by the maximum number of points planned for inventory of any given taxonomic group. Wherever an inventory of vascular plants is planned, the referent for establishing grid density will be the number of plots planned for this taxonomic group. Richness of vascular plants species is consistently greatest of any taxonomic group, as is the number of plots required for 90% inventories. Wherever an inventory of plants is not planned and an inventory of birds is, then the number of plots planned for the avian inventory will be the referent; and so on.

Density of grid cells will not equal the number of inventory points planned for the most species-rich taxonomic group in any given stratum. Rather, total number of grid cells (i.e., grid density) will be some multiple of this planned number of sample points. The multiplier will be a function of uncertainty in the number of points ultimately required to achieve 90% completeness, the use of stratification, and variation in estimated species richness among strata. The multiplier to reflect uncertainty will be about 1.5. Where stratification is used, an additional multiplier of 1.5 will be applied. Thus, in the case of Salinas Pueblos Missions NM (SAPU), where an inventory of birds, mammals, and amphibians and reptiles is planned, and assuming that stratification will be used, total number of grid cells should equal 26 (number of plots planned for the bird inventory) $\times$ 1.5 $\times$ 1.5 = 58. The value 1.5 is our best guess for the uncertainty multiplier.

The multiplier for stratification follows from the assumption that grid density will be higher in strata where S is expected to be greater and lower in strata where S is expected to be less, as well as the assumption that grid density should be as great as the densest sampling needed in any area of a given NPS unit. A value of 1.5 for this effect amply captures the ratio of natural-log transformed values of S for the richest and poorest strata of representative mammal and plant communities (e.g., about 10–30 for mammals [Sheperd and Kelt 1999] and about 50–150 for vascular plants [Stohlgren et al. 1997]). Allocation of samples among strata will be proportional to the natural-log transformed expectation of S for each, summing to the total estimated for planning purposes.

Once a decision has been made whether to use strata or not, the strata identified, grid density determined, and the grid located, then grid cells will be chosen for sampling. In most park units, several passes will be made to select grid cells, reflecting the different sampling densities of different taxonomic groups, and within groups, different strata. For any given taxonomic group, grid cells initially will be randomly selected over the entire grid sufficient to identify the number planned in the stratum with lowest density of sampling. For the same taxonomic group, grid cells should be selected within the next-most-densely sampled stratum, accounting for previously selected grid cells (i.e., without replacement), sufficient to identify the number planned there; and, so on, for all of the strata. This process will be repeated for each taxonomic group planned for inventory within a given NPS unit. Where stratification is not used, only one pass will be required to select cells. The pass during which a cell was selected for sampling will be permanently registered with that cell.

Given that the density of grid cells in any given NPS unit will be finitely related to the maximum expected sampling density, a certain number of cells will be sampled for all taxonomic groups planned for inventory and others for various permutations of taxonomic groups. This approach will facilitate the spatially-explicit integration of some information among taxonomic groups in inventoried parks, while allowing for sensitivity of sample point location to differences in species richness and stratification among taxonomic groups. Where there is spatial redundancy of sample points among taxonomic groups, the opportunity for integration will be enhanced because annual schedules for sampling will be the same among groups (see below under ***Temporal arrangement***). Thus, synchronization will be required for sampling different taxonomic groups at these redundant points.

In places, adjustments to the selection of sample points may be needed, especially for sampling plants and non-volant vertebrates. This is likely to occur in park units where there are extensive barren areas that are not mapped or otherwise are poorly known (e.g., bare rock). The optimal resolution to this kind of problem is stratification followed by allocation of points to strata based on expected *S*. However, in this situation, the requisite *a priori* information is not readily available. Rather than expend scarce time and resources over-sampling poorly known, impoverished areas, additional resources will be applied early in the sampling process. Where aerial photographs are available, researchers will review photos of all the sample points to determine which ones occur on bare rock. These cells could be masked from the grid, and a new selection of cells made, and so on, until an acceptable number of points on rock was obtained. Alternatively, sample points could be visited and passed over if they were barren, in which case a "surplus" of points would ideally have been initially identified. Such approaches and others of a similar nature compromise the basis for statistical inference, but we view them as better alternatives to unproductively expending scarce resources at barren sites.

4.1.3.2 Purposive sampling

In addition to grid-based randomized sampling, principle investigators will sample known "hotspots" or other unique habitats. Such locales also will be sampled as detected if they are not part of the random sample. Hydrologic features and edaphic anomalies are foremost amongst these special features. Wetlands on the Southern Colorado Plateau are known to support rich and unique assemblages of species and are the sole habitats of amphibians in an otherwise unwatered landscape. Purposive sampling of these sites is not only important to gathering information on species of special interest, but also a means of efficiently adding to species lists. Such an approach is especially important to sampling vascular plants. Using only a randomized design, sample sizes required to reach 90% completeness would be prohibitive for this taxonomic group.

Because samples obtained by purposive sampling will not conform to assumptions implicit to the grid-based randomized design, they will not be used for statistical inference. Only plots from the grid-based sample will be used in mark-recapture models to estimate species richness and the related 90% goal (see below under ***Estimating species richness***). However, species detected during purposive sampling will be included in the total species list and counted in the tally towards attainment of the goal. We also plan to use the data concurrently collected by purposive and grid-based sampling to compare patterns of species accumulations the two approaches.

4.1.3.3 Temporal arrangement

In general, field work for individual projects will be completed within 2 years. Although more years of sampling compared to fewer almost always yield more complete biological information, there is evidence that, with a good sampling design, most species will be detected within two years (MacNally 1997). Two-year duration also facilitates scheduling to meet annual budgetary constraints (see **Schedule** below). As indicated above (***Spatial arrangement***), where different taxonomic groups are being sampled at the

same point, sampling of all will be on the same annual schedule so as to increase comparability of results among groups by controlling for annual variation in weather.

Approximately one-half of the planned points will be sampled the first year, and another subset of points, the second year. Points sampled the first year will be from a random subset of cells selected as previously described (see above under ***Spatial arrangement***). The remaining cells will be sampled the second year, but potentially revised in number based on an appraisal of sampling adequacy during the first year. According to our planning protocols (see above under ***Number of sample points***), expected completeness after the first year can be calculated as:

$$(MS * \ln[nsp + 1] / 0.693) / ES,$$

where *MS* is the initial estimate of number of species detections per plot, *nsp* is the number of points sampled the first year, and *ES* is the expected species richness from Table 5. This expectation can be compared with completeness estimated from the list of species documented the first year (*ofys*) and richness of the species pool estimated from the same data (*OS*; see below under ***Estimating species richness***).

If expected completeness is less than the data-based (observed) estimate of completeness, then no adjustments will be needed in the second-year sample. However, if expected completeness is greater than observed, more points will be sampled the second year than were initially planned. The multiplier for increasing number of plots will be calculated as:

$$(\ln[efys + 1] / \ln[ES + 1]) / (\ln[ofys + 1] / \ln[OS + 1]),$$

where *ES* is expected species richness used for planning purposes and *efys* is the expectation for number of species detected the first year (= $MS * \ln[nsp + 1] / 0.693$; see above). The natural-log transformations account for decay in species detections with addition of plots. Additional samples will be randomly allocated to grid cells not previously allocated to sampling that taxonomic group (i.e., without replacement relative to previous rounds of sample point allocation for the group).

4.2 Estimating species richness

Species richness (*S*) will be estimated from inventory data after the first and second years of data collection for each inventoried taxonomic group in each NPS unit (**see Temporal arrangement** above). These estimates will be compared with counts of observed species to determine inventory completeness. There are many potential ways to estimate species richness, including master list, rarefaction, and mark-recapture methods. Because expert-compiled master lists will be available for vertebrate species in all inventoried park units, these lists will be used as one check against completeness, weighted as described above under ***Summary of inventory completeness*** in section **2**. However, in all cases, quantitative statistical methods also will be used to estimate *S*.

Wherever possible, we plan to use models based on mark-recapture designs for estimating species richness (Dawson et al. 1995, Boulinier et al. 1998, Nichols et al. 1998, Hines et al. 1999). There are many mathematical models that can potentially describe the rate at which species detections accumulate as a function of area or number of plots. However, virtually all of these models assume that probability of detection is constant among species within and among plots, and among years and seasons. Moreover, the performance of many mathematical models as predictors of species accumulation is similarly highly dependent on the structure (distribution and relative abundance) of the sampled taxa (Keating and Quinn 1998, Keating et al. 1998). By contrast, there are models for estimating population size (i.e., species richness) based on mark-recapture (i.e., repeat detections of species) that can explicitly accommodate differences either in detectability among species or within species over time caused either by changes in community structure or efficiency of detection methods (Boulinier et al. 1998, Nichols et al. 1998, Hines

et al. 1999). Indeed, major heterogeneity in detectability of species for these reasons has been documented for birds (Dawson et al. 1995, Boulinier et al. 1998, Nichols et al. 1998).

Application of mark-recapture models to the estimation of species richness is described by Nichols et al. (1998) and Hines et al. (1999). These models are available in a software package called COMDYN on the Patuxent Wildlife Research Center web site at http://www.mbr-pwrc.usgs.gov/comdyn.html. The model that includes heterogeneity of detection probabilities (M_h) for estimation of S uses total number of species detected and the numbers of species detected at each sample point, in order. Where the mark-recapture models in COMDYN produce suspect results, we will use Lee and Chao's (1994) theoretically related incidence-based coverage estimator (ICE) as an alternative and check. ICE is available in the EstimateS software package published at http://viceroy.eeb.uconn.edu/estimates (Colwell 1997).

4.3 Field methods

4.3.1 Birds

We established the following objectives for bird inventory studies in the Southern Colorado Plateau park units:

1. Systematic Surveys – Document presence/absence of bird species, and their distribution and abundance in habitats that were historically under-sampled or not sampled at all.
2. Identify Critical Habitats – Document locations of key breeding and non-breeding habitats where current records are lacking.
3. Species of Concern – Document presence/absence of birds of special management concern that are known or expected to occur in the park units based on habitat or historic records.

4.3.1.1 Estimating Richness, Relative Abundance and Density of Breeding Birds

It is rarely possible to count all of the birds that are actually present in an area. Consequently, we emphasize methods that will allow us to estimate the proportion of birds that are missed. Below we emphasize the method of distance sampling because it is an established method that can be employed by only one person. Distance sampling has been used for more than 30 years to estimate animal abundance. It is currently being used to sample birds in many national parks, for over 20 years in Hawaii, and has been found to be a reliable method for estimating relative abundance and population trends for most bird species (Fancy 1997, Nelson and Fancy 1999).

Distance sampling allows for the estimation of detectability. Because many birds are undetected, distance sampling provides a means for estimating the number of individuals that are not seen or heard (Buckland et al. 1993), in turn providing a means for estimating total densities.

Distance sampling includes two approaches to estimating density: line transects and variable circular plots. Both will be used for sampling depending on the habitat type (see Ralph et al. 1995). In both sampling techniques the horizontal distance is estimated between the observer and the bird for each individual of each species heard or seen. For many surveys, the majority of birds are heard but not seen, and the observer estimates the distance to a tree or bush or other object where they think the bird is located.

Line Transect Sampling

For line transect sampling, an observer walks a transect and records either the perpendicular distance to each bird heard or seen or else records the sighting angle and sighting distance. Line transects can be very

efficient because data are continually collected as the observer walks the line. By contrast, during variable circular plot sampling (see below), birds are counted only at stations located every 250 m or some other interval along the transect.

Variable Circular Plot Sampling

Variable circular plot (VCP) counts are the preferred approach in patchy habitats where the objective is to correlate bird data to vegetation or other habitat information, and in dense or rugged terrain where walking a transect would be unacceptable. In the case of VCP sampling, the observer stands at a sampling station and records the horizontal distance between the observer and the bird.

Depending on stand size and shape, point count stations will be located 250 m apart in each habitat type. Between each habitat type a 200 m buffer will be implemented. Three visits will be conducted to cover the period in which the greatest number of passerine bird species would be exhibiting breeding behavior, such as territorial calling and singing. Visits will start at one/half hour after sunrise and be completed by 1000 hours. No visit will last beyond that time. At each station, one observer will record all individual birds seen or heard for 7 minutes with counting subdivided into 3 periods: 0-3 minutes, 3-5 minutes and 5-7 minutes. Counting will begin 1 minute after arriving at a station. Bird detections will be recorded to the nearest 5 meters. Laser rangefinders will be used to estimate distance. These rangefinders can measure distances to rocks or trees where birds are detected within 1% accuracy.

Flyover species will be recorded in the same time periods, but with no estimates of distance. Additional notes will be taken regarding whether detections were songs, calls, or other (e.g., drumming wings), whether the detection was aural, visual, or both, and whether the bird was detected at a previous point count station to avoid double-counting individuals. Birds flushed while walking between point count stations will be counted and their distance estimated to the nearest point count station. Field sheets will be modeled after those recommended by Ralph et al. (1995).

4.3.1.2. Data analysis

We will estimate species richness using models based on mark-recapture designs (see above under **Estimating species richness**). This procedure does not identify species that are not seen; rather, it provides an estimate of the number of species that have not been detected but are probably present. Estimates of species richness will be used to assess adequacy of the sampling technique and the sampling done to date.

Relative abundance and density of each species with >50 detections will be calculated for each habitat using DISTANCE (Thomas et al. 1999). Distance data will be used to model probability detection functions, from which we can obtain unbiased estimates of abundance for each species (Buckland et al. 1993). For this analysis, distances will be placed into intervals such as 0-10 m, 11-20 m, 20-30 m, and analyzed as grouped data. Such grouping minimizes the effects of error in estimating detection functions.

There are many advantages to using distance-sampled data. For one, multiple surveys can be combined to increase sample sizes. By combining surveys, it is possible to estimate densities of species, even in situations where only 1 or 2 birds are detected while sampling many stations. Bias of estimated abundances also can be reduced by adjusting for the effects of covariates such as the observer, vegetation cover, and detection distances. Historical count data also can be used in situations where NPS units collected bird data using unadjusted point counts and later switched to VCP counts.

4.3.1.3 Additional breeding and non-breeding surveys

Most bird survey methods provide good information for common species and relatively sparse information for rare or secretive species. This does not mean the survey method is invalid; it is simply a

reflection of the difficulty of sampling rare and secretive species using general methods. Therefore, in addition to point counts, an area search of all habitats during breeding and non-breeding periods will be completed to increase the chance of detecting rare and secretive species that occur in the park units.

Personnel will go to the different habitats where point counts have been established in the units and record all species they see or hear. These surveys will be conducted in conjunction with the standard survey protocol (i.e., point counts) during the breeding season. During the non-breeding season (November – February) we will conduct three additional visits. These surveys will be conducted between sunrise and 1000 hours. Extra visits will be made in the late afternoon that may detect the presence of vultures, buteos, or other birds not found in early morning (Robbins 1981). Survey data will include species encountered, habitat, location, dates, and evidence of breeding status (i.e., courtship behavior, nests).

4.3.1.4 Species of concern

Playback recorded calls will be implemented to increase the probability of detecting rare species of concern. Broadcasting tape playbacks has been effectively used to survey for marsh-breeding (Marion et al. 1981) and endangered species (e.g., Southwestern Willow Flycatcher; Sogge et al. 1997). We will include the playback procedure in likely habitats, increasing our chance of detecting these targeted species (Verner and Milligan 1971). Broadcasting of taped calls will occur in habitats where standard count surveys are not being done or after the standard count period is completed.

4.3.1.5 Nocturnal Species

Nocturnal birds (i.e., owls) will also be surveyed using taped broadcasts. Owls are usually surveyed using tape broadcasts of the owl species songs or calls (Springer 1978, Forsman 1983). These surveys will be conducted in all habitats that may be occupied by owls or where historical sightings have been noted. Tape broadcasts will be played for 15 minutes at each designated point. Survey times will occur between 1 hour after sunset and 1 hour before sunrise. We will conduct 2 surveys during the breeding season and 2 surveys during the non-breeding season. Survey data will include species encountered, habitat, location, dates, and evidence of breeding status (i.e., courtship behavior, nests). All other nocturnal and crepuscular species will also be noted.

4.3.2 Mammals

4.3.2.1 Sampling Overview

Our use of the word "inventory" as applied to mammals in this network follows the definition given in "Guidance for the Design of Sampling Schemes…." If the primary objective is to obtain as complete a mammal species list for an area as possible, the investigator should use a wide variety of methods for detecting animals. In addition, the PI should use intuition and past experience to direct search efforts to specific locations where the largest number of species are likely to be recorded. These "directed efforts" may not always yield count statistics that are useful in estimating species richness but they are appropriate when the goal is a complete species list. Although several parks present evidence that a 90% level of documentation has been reached, this is not true for most parks. Baseline inventories for small mammals have never been conducted on many Southern Colorado Plateau parks, and directed efforts conducted by knowledgeable investigators are an appropriate approach for this work.

Where possible, we will conduct inventories for mammals on plots that have been selected in a stratified random fashion. It seems likely that stratification will be on the basis of selected landscape features (e.g. slope, aspect, elevation, soil type, etc.) rather than plant associations as most parks do not have vegetation maps of sufficient detail to be used; there also is concern that the limits of plant communities will change

over time. Theoretically, it should be possible to "piggy back" on plots selected in a similar fashion by those working on other groups.

The smallest of parks (i.e.., 100s of ha) should lend themselves to more or less complete coverage with no need to randomly select samples. Larger parks that are not diverse topographically can be sampled using randomly-chosen points (quadrats) in which both quadrats and starting points for work within the quadrat can be chosen randomly. Large, topographically diverse parks with no history of baseline inventories can be stratified using elevation, aspect, or similar feature and sampling points chosen by random selection (i.e.., stratified random cells within a grid of the park) to the extent possible.

Areas that are remote, logistically challenging, or sensitive will be excluded from quadrat selection but not necessarily from inventory work as it may be possible to sample limited areas for selected species. Several parks have been the beneficiaries of previous inventories, although rarely have inventories been conducted on random plots. Nonetheless, studies of so-called "representative areas" have provided considerable information on mammals of the Colorado Plateau and are responsible for documenting new species on some parks. For parks with some history of inventory, and where the previous work seems satisfactory, additional areas that have not been studied will be targeted for directed efforts. Where possible, inventory study plots will be chosen for compatibility with long-term monitoring sites as this effort proceeds.

Many species of mammals are habitat specialists (e.g., cliffs, marshes, streamsides, etc.) and may occur only in limited areas of a park. Plots chosen at random, as well as designs using traps in grids, may miss such species and their habitat. Bats that are not roosting can be captured only at sites where they come to forage and drink and not at random stations. We concur that such special areas of focus at each park should be mapped and then evaluated as candidates for surveys in an "unequal-proportion" approach. It seems possible that such areas may ultimately be recommended as likely candidates for long-term monitoring. In this regard, we generally advocate monitoring of such special areas on parks rather than just simply monitoring individual species.

Medium-sized diurnal mammals such as lagomorphs and squirrels are more likely to be observed than uncommon, small, and nocturnal mammals, and certain observational techniques (e.g., line or strip transects) can be used. Common and widespread "weedy" species (e.g., *Peromyscus maniculatus*) may be more likely to be captured in randomly chosen areas and such species can also dominate traplines and exclude rarer species. Large mammals, although theoretically easy to document due to their size or aggregations, may have home ranges several times larger than small parks and may be elusive enough so that their presence has to be inferred from tracks or scats.

4.3.2.2 Methods

Sampling strategies and methods for mammals will vary from park to park, depending upon the specific objectives as specified in detailed study plans, and perhaps upon availability of plots developed for other groups that also can be sampled for mammals. A combination of designs and methods will provide the most complete coverage of mammals for each park. For example, pitfalls are most effective at capturing shrews, mist nets and bat detectors for bats, various sorts of traps for small and medium-sized rodents, larger traps or firearms for some medium-sized species (e.g., rabbits), and a variety of observational and tracking methods for carnivores and ungulates. Data on larger species (furbearers and game species) may be available from park records and state wildlife investigations. Although several investigators have used remote automated photographic stations to advantage, these studies are usually species-specific and we know of no case where such stations have been used in large-scale studies of species richness.

4.3.2.3 Estimating Species Richness

Inventory methods for mammals of the plateau will follow guidelines enumerated by Kunz (1988) and Wilson et al. (1996). Kunz' (1988) book provides details on an array of capture and research techniques for bats. Wilson et al. (1996) provide a comprehensive collection of papers on measuring and monitoring mammalian diversity including several on aspects of design and randomization. Estimation of species richness of mammals is still a developing field, perhaps in opposition to such studies of plants or birds.

For mammals in general, we envision a seasonal two-year effort for those parks needing partial or complete inventories. Most work will be done in the summer season and a schedule will be developed so that each park is visited at a different time during the two years of visits. It will be possible to work at some parks in this network in late spring or early fall. Work at other times of the year will depend on specific needs as outlined in the individual statements of work; capture of data from park records and files would be done off-season. In some cases, work may last three years on selected parks, depending on the vagaries of climate as well as success in confirming species occurrence.

Shrews are vastly undersampled on the plateau and where complete inventories are called for, some effort will be put into pitfall trapping. Although sites for pitfalls can be chosen randomly, aspects of shrew biology should be applied, as most species of Sorex have a preference for more mesic, litter-rich sites. Small plastic cups or buckets, and even bottles, have proven effective as pitfalls for shrews; we will allow the linearity of suitable shrew habitat to determine whether pitfalls are set in grids or lines. In suitable habitat we will install pitfalls at 5-m intervals. Water shrews can be most effectively sampled at the edge of small streams with pitfalls spaced at wider intervals (15-20m). Where possible, we will operate pitfalls with drift fences to help "corral" shrews and direct them to the pitfalls. Pitfalls will be unbaited, kept dry, and checked frequently so animals can be released alive. Pitfalls also are effective for capturing some small heteromyid rodents, such as pocket mice, and we will use pitfalls for these species in suitable habitat. Effort and catch will be quantified for each area based on numbers of nights that a given number of pitfalls are operational (pitfall-nights).

Small- and medium-sized rodents (including some ground squirrels) are effectively trapped in livetraps such as those made by Sherman or wire traps such as those made by Tomahawk and others; animals can be released unharmed following identification. For inventory efforts where densities of small mammals are not required, livetraps can be effectively set in lines 150 m in length in appropriate habitat with starting points determined randomly. Grid designs of traps are more appropriate where densities are needed, as in long-term monitoring, but may miss some species (e.g., certain microtine rodents). We will use two traps per station, and stations will be spaced at 15-m intervals along the line, and additional lines within the same habitat will be spaced at equal intervals. Habitat complexity may require shorter intervals in some cases. Traps will be set for three nights, baited with rolled oats in most cases, checked at least twice per day, and will be closed during daylight hours except for directed efforts on diurnal species. Livetraps will be checked more frequently, up to once per hour, for diurnal species. Where possible, livetraps will be set at habitat features (e.g., logs, trees, burrows) but within 2 m of the station point. Effort and catch will be quantified based on numbers of nights a given number of traps are set (trap-nights).

In selected areas and for selected species, "snap" traps that kill rodents may be used. To the extent possible, kill traps (e.g., Museum Specials, Victor rat traps) will be set in a fashion consistent with livetraps as described above. Kill traps are effective for species that are reluctant to enter box (Sherman-style) traps and are useful and effective in logistically-difficult areas (e.g., cliffs) where a sufficient number of box traps may be difficult to carry or set. A snap trap costs less than half the recommended Sherman trap (LFADTG; ca. $15.00 each), and life spans under normal usage are equivalent. All rodent

sampling will be consistent with published guidelines for reducing exposure of trapping personnel to hantavirus and other infectious diseases.

4.3.2.4 Bats

Bats will be sampled in several ways, depending on park size, availability of known or suspected roosts, and presence of water sources. Where roosting sites are known or suspected, the sites will be observed without disturbing the bats as the great likelihood is that such aggregations will be maternity colonies (females with young). Such roosts can be selectively and carefully netted from the outside to determine species identification. We believe that detection of roost sites using radio-transmitters affixed to bats is a research question that is not appropriate for inventory purposes. For bats roosting in small numbers, they can be hand-captured, identified, and released; but such attempts should be used cautiously in maternity colonies. On parks where bats are not readily captured, we will develop walking transects to search for bat presence based on observations of guano and insect remains.

All water sources larger than 1 m (arbitrarily) should be included in the list of "unequal-sampling" focal sites, visited if possible and a decision made as to feasibility of erecting mist nets for capture. (Most pools at "hanging garden" sites are not suitable for drinking by most bats, are typically difficult to net, and netting may damage fragile plants and substrates.) Suitable sites (e.g. streams, creeks, stock ponds, etc.) should be netted two to three times per summer season no more often than every four to five days, depending on past success. Where inclement weather results in low capture success the site will be revisited sooner. Effort with mist nets will be quantified based on size and numbers of nets set each night (net-nights). At most water sources on the plateau, 6- and 10 m nets are sufficient although longer nets (14- and 20 m) may be needed at times. Bats will be carefully removed, sex, reproductive status, age, and species recorded, and released unharmed. In some cases it may be useful to take selected measurements (mm) or body masses (g). Where there are no water sources over which mist nets can be deployed, it may be possible to net areas that intuitively appear to experienced investigators as flyways through which bats might travel. Personnel handling bats will be vaccinated against rabies using the rabies pre-exposure regimen with subsequent testing of rabies antibody titers.

In selected parks or areas, especially those with limited roosts and water sources, it may be necessary to use a bat detector to determine the presence of bats. Sample points or transects can be randomly selected and both species diversity and relative activity levels can be determined at a pre-determined number of points along the line. Most North American investigators use the Australian bat detector Anabat, made by Titley. Typically, calls are recorded on the hard drives of laptop recorders and saved for subsequent analysis. Calls also can be saved on high-quality tape recorders or compact disk devices for analysis. Although randomly-chosen bat detector transects may be very useful in long-term monitoring as well, a variety of caveats have been raised about their use in this fashion (e.g., O'Shea and Bogan 1999) and we recommend that for parks on the SCP, efforts with Anabat be restricted to the identification and confirmation of bat species occurring on the park. This should provide a more cost-effective effort, in conjunction with roost observations, searches, and netting. Also, some species of bats have audible echolocation cries and experienced personnel can recognize those calls to help document presence of some species.

To confirm the presence of some medium-sized terrestrial mammals and all large mammals, especially carnivores, we will use a combination of methods including historic and recent museum records, park staff and visitor files (with caution), field observations (for tracks, scat, sign) by those conducting mammal surveys, photographs, and relevant information from state fish and game agencies. Most small parks will be too small to have any resident carnivores; rather, the carnivore's home range may encompass the park or at least the appropriate habitat components that occur on the park. Likewise, for some larger parks and some wide-ranging species of carnivores much of the range of some species will be off the park. Rather than mount an expensive and time-consuming effort to trap such species, we

recommend that other information sources be used. We believe that this will provide a landscape-level overview of carnivore presence that should be more useful to parks in helping to understand the importance of the park to medium- and large-sized mammals within a regional context. Larger parks will certainly have resident medium and large mammals, but we recommend the same methods be used, except in the case of questions about occurrence of selected species on some parks or where identified needs exist.

Finally, there is a suite of perhaps 20 or so medium-sized mammals, many diurnal, that are scansorial, arboreal, fossorial or semi-fossorial, and aquatic. Traps (e.g., for gophers) and trapping methods are available for most of these species, but some of these species are difficult to trap and some require sedation for handling. For many of these species the most cost-effective way to document presence for initial inventory is probably by observations documented with photographs by knowledgeable personnel and by specimens taken with a firearm. Park records may help confirm presence of some of these species as well.

4.3.3 Amphibians and Reptiles

The primary objective of this research is to inventory 90% of all reptile and amphibian species in each park unit. A secondary aim is to determine general abundance and distribution (e.g., which are common and which are rare in each park). For small units, this will entail sampling the entire unit. For larger units, sampling will be stratified by habitat. Sampling will take place when reptiles and amphibians are active, and breeding is likely, generally mid-May to the end of September. Sampling will occur throughout this season, focusing in May and June on early-season lizard activity and spring-breeding amphibians, in July and August on reptile hatching and monsoon-breeding amphibians and snakes, and in September on the last of the hatching reptiles and pre-hibernation snake activity.

Sampling design considerations are covered for all taxa in Section 4 of this proposal. The approximate number of sampling points necessary to detect 90% of the herpetofauna in each park is given in Section 4, Table 5. Sites for sampling herpetofauna will be selected in each habitat within each park using a stratified random procedure, in conjunction with other taxa researchers. However, sampling sites will not be randomly chosen when detection of amphibians and species with specific habitat requirements is desirable. For example, all permanent and semi-permanent bodies of water in each park unit should be sampled during the spring and summer rainy periods for breeding amphibians. Rock outcrops (see Dalrymple et al. 1968 for a discussion of different types) provide critical habitat for species such as chuckwallas and desert night lizards, as well as winter hibernacula for many snake species. Road driving (see below) will cover all habitats adjacent to a strip transect (the road).

4.3.3.1. Collaboration on Mammal Pitfall Trapping

Pitfall trapping is another method commonly used to detect reptile and amphibian species presence, as well as to conduct population studies (Drost et al. 2000 unpubl., Drost and Nowak 1997, Campbell and Christman 1982). We have chosen not to use this method for reptiles and amphibians due to its being time and effort-intensive. However, we will work with mammalogists conducting pitfall trapping for mammals in each park to ensure that all reptiles and amphibians that fall into pitfall traps are properly identified to species. Prior to the beginning of each field season, we will meet with these technicians to train them in reptile and amphibian species identification. We will request copies of herpetological data produced by pitfall trapping, and will incorporate any pertinent information thus gleaned into our final report.

4.3.3.2 Time-constrained searches

Time-constrained searches (TCS) are a version of visual encounter surveys defined by Crump and Scott (1994) in which not only the amount of time spent searching, but also the area covered, are standardized.

TCS consist of walking systematically through each habitat within the sampling area for a specified amount of time, searching all reasonable areas within that habitat, and recording reptiles and amphibians encountered (Drost and Nowak 1997, Scott 1994). TCS are most applicable when the primary goal of fieldwork is accumulation of faunal lists (Scott 1994). This method yields a number of individuals and species collected or observed per person-hour. The focus of these surveys will be to document species present rather than capturing and processing each individual seen.

We recommend that time-constrained searches be conducted by one or two herpetologists, and last 60 minutes (one or two person-hours, depending on the number of observers) per habitat to avoid observer fatigue. To be consistent with the Northern Colorado Plateau Network methods for reptiles and amphibians, we recommend that the area covered by each TCS be one hectare (ha) in size; however if a given microhabitat is not structurally or vegetatively diverse (e.g. short-grass prairie), a greater area could be covered during the one-hour sampling period. This method is heavily influenced by the skill of its users, so we recommend only using skilled herpetologists familiar with the local species, capable of recognizing species, age classes, and sexes at a distance. Care must also be taken to define and stratify all major habitats to be sampled a priori, to ensure that each habitat is sampled for an equivalent amount of time (Scott 1994). Each habitat should be sampled during every sampling trip to ensure representative temporal coverage.

We recommend supplementing road cruising surveys (see Section 4.3.3.2) with nocturnal TCS in parks where there are few roads, and in habitats without roads running through them. Nocturnal TCSs will be conducted in the same plots searched by day, during the evening following the daytime searches, using the technique outlined above. However, unlike diurnal TCSs where each person can search independently, for safety reasons, technicians will work in 2-person teams to conduct a nocturnal TCS. Each team will be considered a single person for measuring time spent searching. Thus a single team would work for 1 hour to achieve a 1 person-hour search.

4.3.3.3 Road cruising or night driving surveys

Driving slowly on roads at night is recognized as an excellent method for surveying some groups of reptiles, particularly snakes (e.g., Bernardino and Dalrymple 1992, Dodd et al. 1989, Klauber 1939, Mendelson and Jennings 1992, Rosen and Lowe 1994, Sullivan 1981). This method is also effective for surveying amphibians (Shafer and Juterbock 1994), particularly in the arid southwest where many anuran species are seldom active during daytime, but can often be found crossing roads on warm, rainy nights. Night driving was determined to be the best survey method for amphibians in two arid Colorado Plateau National Park areas during recent inventories at Petrified Forest National Park (Drost et al. 2000 unpubl.) and at Wupatki National Monument (Persons, 1999 unpubl.).

We recommend that night driving surveys be standardized in the following way:

- Drive a vehicle at slow speeds (20-25 mph) on park roads for 2-4 hours each survey night (ca. 40-80 miles per night).
- Identify all amphibians and reptiles encountered to species, record either alive on the road (AOR) or dead on the road (DOR), sex and age all individuals, as possible.
- Record locations to the nearest 0.01 mile using calibrated vehicle odometers, and later convert these positions to GIS point locations.
- Collect animals found DOR and in good condition and preserve as voucher specimens. Occasionally live animals should be collected for voucher specimens, as needed (see ***Voucher Specimen Collection*** below for details).

In addition to night driving surveys, reptile and amphibian experts should opportunistically record amphibians and reptiles seen on roads during daytime, during the course of travel within the parks. Although less effective and less quantifiable than night driving, due to faster driving speeds and the presence of other vehicles on the road, this is still an effective method for detecting the presence of some diurnal reptiles, such as whipsnakes (*Masticophis*), patch-nosed snakes (*Salvadora*), and horned lizards (*Phrynosoma*).

4.3.3.4 Amphibian-specific methods

Amphibians are important bioindicators due to their dependence on water and to their sensitivity to environmental changes, and there has been recent international attention on the problem of widespread amphibian declines (Dunson et al. 1992, Vertucci and Corn 1996). The methods most effective for detecting amphibians are night road driving (see above), audio strip transects, and diurnal visual encounter surveys (Crump and Scott 1994). Audio strip transects consist of walking systematically along a body of water (ponds or streams) at night during amphibian breeding times, and recording the number and species of amphibians heard calling or seen. This method is extremely effective when breeding locations are known, and it may also be used if breeding locations are detected during another method, such as road driving. Counts are used to estimate relative abundance and composition of species, relative abundance of individual calling males, habitat use, and timing of breeding of different species. Diurnal visual encounter surveys consist of walking through a habitat for a prescribed time period looking for amphibians. They are a type of time-constrained search focusing on aquatic habitats, and effort is expressed in the number of person-hours searching in each habitat. This type of survey in parks on the southern Colorado Plateau would focus on permanent bodies of water and temporary pools, and its utility would be in detecting evidence of breeding, specifically searching for egg masses, tadpoles, and metamorphic (newly terrestrial) individuals.

4.3.4 Vascular plants

The principal objectives for work on vascular plants are to document 90% of the species present in parks, to survey for special status and exotic species, and to provide baseline information for park planning and resource monitoring. In parks that need vegetation inventories, we will use a sampling approach to estimate when 90% of species present in a park have been encountered.

As noted elsewhere in this plan (see above under **Spatial arrangement**), there are two basic approaches to sampling vascular plants: (1) complete inventory of small habitat patches or community types of special interest, and (2) sampling by random selection on a systematic grid with or without differential density of sample points in pre-determined strata (e.g., vegetation, geology, etc.). The first approach is intended to sample all known sites of a particular important, rare, or special status community, including springs and seeps, wetlands, hanging gardens, and relict communities. The second approach is based on landscape sampling, potentially using a GIS coverage, either of topography, geology, geomorphology, soils, or vegetation.

Within the second approach, several methods can be used to sample vegetation at each point. These methods can be divided into two basic categories: (1) area searches, or (2) some form of area or plot sampling. Below, four different sampling schemes differentiated by field methods are listed:

1. Sample entire area × area search (may include vegetation plots)
2. Sample based on systematic grid × area search
3. Sample based on systematic grid × relevé
4. Sample based on systematic grid x modified Whittaker plot

These methods are detailed below. For basic inventory work, a combination of an area search and one or more relevés (Rowlands 1995) or modified Whittaker plots (Stohlgren et al. 1997) will be used. If the relevé centers or Whittaker plot corners are permanently marked, then future monitoring can be done by repeat sampling at set intervals. Pre-sampling and analysis of plot data from other projects in similar vegetation types will be done before the actual sampling begins, to determine the method most likely to give estimates of species numbers that approach the 90% standard.

4.3.4.1 Area searches

By this method, the area around the sample point is thoroughly searched for species presence. A definite area will be defined for part of this search. We do not yet know the minimum size and number of plots needed to adequately sample plant species within a stratified area; however, one hectare size plots (Davis and Halvorson 2000) will be used during the first year. The defined area will allow the sampling to be repeated during different growing seasons, and if desired, will also allow comparability from year to year. This does not preclude additional search of larger areas, but does ensure the collection of information on species numbers that can be used in projecting total species numbers. This technique, combined with one or more relevé plots, or with Whittaker plots, will be used for basic floristic inventories in the parks.

4.3.4.2 Plot sampling

A relatively simple relevé method will be used where detailed quantitative data is not required. In this technique, a circular plot of specified dimensions is positioned in the community of interest, and species presence is recorded within the area. A standard area is 0.1 hectare (circular plot diameter of 17.84 meters). A calibrated estimate of cover for each species is made using either calibrated percentage estimates or ranked scale of abundance from 1-5. Estimates of total canopy cover and vegetation height by strata, environmental features of the relevé and notes on disturbance also will be collected. The relevé methods are described at the USGS/NPS vegetation mapping web site (http://biology.usgs.gov/npsveg/) and in Rowlands (1995). If this relevé is permanently fixed using permanent marking, it can be incorporated into a future monitoring network. Estimates of amount of time for this technique vary from ca. 20-60 minutes/relevé depending on vegetation complexity and experience of the field crew. All exotic species encountered in the relevé, in the relevé environs, or encountered in transit to the relevé will be recorded. A simple protocol for notation of such encountered exotic species can be found in the Southwest Exotic Plant Mapping Program (SWEMP) collaborator's manual (Thomas and Wynne 2000).

4.3.4.3 Surveys for Special Status and Exotic Plant Species

Surveys for special status and exotic plant species are generally based on known or predicted habitat preferences and distributions. Many rare plant species on the Colorado Plateau are edaphic endemics, and large-scale sampling is best done with stratification by habitat, geological substrate, elevation, etc. Methods of monitoring plant populations can also be adapted for counts of abundance. Each species is likely to require different methods to determine distribution and abundance. For example, of two federally listed species in GLCA, one is monitored via permanently located circular plots while the other is monitored along permanently located transects. For exotics, protocols described in SWEMP (Thomas and Wynne 2000) will be followed, and additional monitoring and mapping will be done at some parks.

4.3.4.4 Approaches to Sampling in NPS Units

The smallest NPS unites (AZRU, HUTR, NAVA, and YUHO) will be inventoried by area searches encompassing the entire unit (see above, ***4.3.4.1***). The smaller units will also be sampled using the one hectare and relevé plots (the size of the one hectare plots may be modified after initial sampling results are analyzed). Sampling points will be located using grids or by grids combined with stratification, depending on the size and complexity of the sites. The approach to sampling larger units will depend on

whether the focus is on a general inventory or surveys of special status or exotic species. Where an inventory is planned, and the vegetation is relatively homogeneous (e.g., GLCA), grid-placed defined area searches and relevés will be used. Where surveys of special status and/or exotic species are planned (BAND, CHCU, GRCA, MEVE, PETR, and WUPA), grid-placed defined area searches will be used, with placement stratified by habitats likely to differentiate the distributions of species of interest. In some cases, the entire habitat for sensitive species may require survey.

5. Data management and Voucher Specimens

5.1 Data Management

Guidelines from the national Inventory and Monitoring Program include goals for data management. These goals are to update the NPSpecies data base, Natural Resource Bibliography, the Dataset Catalog, and to produce spatially oriented data bases for use in GIS products. The information is to be provided to the parks in accessible formats. Data collection and management are integral parts of the Southern Colorado Plateau inventory and monitoring program. Efforts will focus primarily on the production of spatially oriented database tables and themes in a GIS framework, with continued work on the NPSpecies, Natural Resources Bibliography, and Dataset Catalogs. The staff of the Southern Colorado Plateau program will work closely with the Northern Colorado Plateau program to develop database standards and formats that are compatible and to share resources whenever possible.

The purpose of the spatially-oriented part of the project is to provide GIS technical and database assistance to the Southern Colorado Plateau parks and principal investigators. The effort will focus on technical support and technology transfer to natural resource managers and scientists in order to provide spatial and tabular database information critical to the project. Creation and dissemination of these databases will include biological resources fundamental to NPS units on the southern Colorado Plateau. The data management portion of the project has the general goal of developing and maintaining digital tabular and spatial databases in a geographic information system (GIS).

The procedural objectives of the database creation and management are two-fold:

1) standardize tabular and spatial database methodologies and protocols for creating the GIS database; and,
2) acquire both digital and non-digital data themes for inclusion into a digital inventory database.

The primary task in developing a successful database is to standardize database creation methodologies and protocols. Once spatial scale issues, accuracy standards, study area boundaries, and database development protocols are defined and created, data theme development can begin. Specific objectives of the digital map database will focus on assembling and evaluating existing digital tabular and spatial databases for incorporation into the overall database. Linking of related tabular biological information with spatial attributes can be incorporated into the database if spatial information is readily available. Any shortcomings in the existing tabular and map database will be evaluated and new data will be investigated for incorporation into the GIS database.

Currently, many NPS units on the southern Colorado Plateau have numerous tabular and spatially referenced databases or inventories that were generated and completed during past biological and natural resource research efforts. These databases will be converted from static to digital formats using GIS and other conversion techniques. Information will be entered into the database using a variety of techniques, depending on the format, content, and condition of source material and on accuracy and quality requirements. A variety of techniques to store tabular attribute data and to link these data with map

features are available, and can be employed in the development phase and in the management of the databases. All of these approaches are based on the concept of a database management system (DBMS) to define the specific data element types and formats. The relational DBMS model for storing attributes is, by far, the most popular approach in the GIS software industry. The relational model is based on the storage of attributes as two-dimensional tables. A DBMS will allow for describing the particular contents of the database and the formats of data elements. The NPS Inventory and Monitoring office has designed, developed, and tested major components of a DBMS for inventory and monitoring within the National Parks, and we will use their DBMS, or databases that can easily feed into it, wherever appropriate. Other databases (e.g., for the collection of field inventory data for the different taxa groups) will be designed in a standard format that can be used in all of the Colorado Plateau parks, to ensure consistency, comparability, and ease of use of the data collected.

Most data management programs begin by acquiring much needed base data that describe the physical landscape at a spatial scale that is usable by resource managers and scientists. In the case of the NPS units on the southern Colorado Plateau, many of these digital products are available, but some may not be at a spatial scale that is usable for park management, or inventory and monitoring objectives. *We have contacted theGIS program, in the Natural Resources, Research, and Technology office, of the National Park Service Intermountain Region, and requested that they compile a list of available spatial datasets. We have also contacted individual parks with active GIS programs. The Intermountain Region GIS office is also assembling digital orthophotoquad maps on CDs for use in preparing park stratifications and sampling grids.*

The acquisition of any new digital map databases will focus on the most appropriate method to procure the needed data. NPS units that have GIS programs or have developed digital spatial databases will be contacted for potential database information. For park units that do not have spatial databases already, we will create new databases to meet inventory project objectives. Finally, FGDC compliant metadata for all tabular and spatial data will be created, as appropriate for the objectives of the project. Once data is verified, it will be shared on web-based datasets through the CPCESU.

In the field, sampling site locations and capture locations of rare or sensitive species will be recorded using a global positioning system (GPS) unit. Locations will then be archived and/or plotted on topographic maps of the park using ESRI ArcView© or similar mapping software. Field data sheets will be developed that follow the structure of the databases developed for field inventory work. This will facilitate data entry and error-checking. Alternatively, data will be entered directly into hand-held computers. The database structure on hand-held units will mirror the structure of the project databases, and data will be downloaded to a laptop computer, or otherwise backed-up at the end of each day's field sampling.

The inventory and monitoring coordinator (in coordination with the southern Colorado Plateau Inventory and Monitoring Steering Committee) will guide data management. There will be a strong effort to maintain standards and formats for data that will allow comparability with data from the northern Colorado Plateau. There will be a one-half time employee continuing to build on the data acquisition and database development that has been accomplished in the early phases of the program. The Colorado Plateau Field Station will contribute one-half time services of an experienced GIS staff member, and the National Park Service will hire a full-time GS-11-12 data manager. Part-time help will be hired for data-entry.

5.2 Species verification and voucher specimens

5.2.1 Birds

All survey observers will be hired based on their bird identification skills, and they will be given further training on Colorado Plateau bird species identification. Observers will be trained to identify birds by both visual and aural cues. Since 80% of all birds are aurally detected, observers will familiarize themselves with all known species songs and calls. Identification by song will be particularly important for some species such as the Empidonax flycatchers, which are very similar in appearance. For all rare and difficult-to-identify species, field personnel will record detailed notes on appearance, behavior, and calls of the bird. These field notes will be included as appendices to project reports.

Our field methods do not include capture of birds, but birds found dead in good condition will be saved as specimens. Specimens found dead may be stored temporarily in a freezer at the Park or researcher's office. We suggest that specimens be put in a plastic bag (Zip-loc© heavy duty freezer bags are excellent), along with label noting date of find, precise location where found, and collector. Air should be squeezed out of the bag, and the bag securely sealed. If the specimen will remain in the freezer for more than a few weeks, it is a good idea to double-bag the specimen. Specimens will be curated and stored at either at the Museum of Northern Arizona, Northern Arizona University, or the University of New Mexico. All specimens will be affixed with National Park Service issue specimen tags containing information on species, collector, date of collection, collection site, and NPS record number.

5.2.2 Mammals

Some SCP parks are the beneficiaries of recent previous surveys in which voucher specimens have been taken and deposited in accredited museum collections. In particular, the USGS Biological Survey Collection in the Museum of Southwestern Biology, University of New Mexico, Albuquerque, has significant holdings of mammals, and some amphibians and reptiles, from SCP parks. For these parks, most of which are not on the top-priority list for inventory work, it should be possible to rely on existing vouchers for documentation (e.g., for NPSpecies) rather than take additional vouchers. There are few significant taxonomic problems for mammals on the plateau that require additional vouchers, but these should be taken by principal investigators as approved for research, rather than as part of an inventory or monitoring effort.

However, there should be no mistake that voucher specimens, identified to the extent possible, properly cataloged and accessioned, and deposited in accredited museums are fundamental to an improved understanding of occurrence and distribution of vertebrate species and plants on SCP parks. All new inventory work on SCP parks should be properly vouchered to the maximum extent possible. For species where it is not appropriate (e.g., protected species) or feasible (e.g., black bear or pronghorn) to take vouchers, documentation should be provided in some other form. We will attempt to document such species with photographs of individuals, their sign, or scat. For parks with little or no previous inventory work, we will retain small numbers of all species for which voucher specimens can be prepared. We will salvage dead animals whenever possible (e.g., road-killed animals) and will work with each park to process material they may have in freezers on-site.

Museums that currently have holdings of mammals from the SCP include University of Colorado Museum, Boulder; University of Wyoming (inactive), Laramie; University of Kansas, Lawrence; Carnegie Museum, Pittsburgh; Utah Museum of Natural History, Salt Lake; University of Arizona, Tucson; University of Illinois, Champaign; and Biological Survey Collection, Museum of Southwestern Biology, Albuquerque. For mammals we recommend deposition in the Museum of Southwestern Biology; variances to this can be resolved as needed.

For other taxa, voucher specimens should be deposited in accredited collections that already maintain sizeable collections from the SCP, as this provides an economy of effort in data searches and museum visits by professionals or others needing collection information. The various scientific societies (e.g., American Society of Mammalogists) visit and grant accreditation to collections, a process that has not normally been requested by or granted to most NPS collections, although they are frequently listed in compilations of collections.

Some thought should be given to providing at least some initial level of funding to institutions willing to accept vouchers from NPS parks. At a minimum, some estimate of voucher numbers should be made and funding provided for purchase of cases, trays, vials and the like. Long-term support may not be feasible but most collections are always in need of supplies for the initial storage of collections. In addition, some thought should be given to providing support for museums that are asked to perform extensive searches or manipulations. Where possible, it would be desirable to reduce the paperwork associated with acquisition of collections from NPS lands; direct donations by Superintendents of vouchers to reputable and accredited museums would help in this regard. Finally, NPS should cover any cost associated with data capture for ANCS.

Additional thoughts on vouchers: They are critically important as they are the ultimate source of documentation of occurrence of plants and animals on parks. It is also critical that vouchers go to reputable collections with a good "track record" of providing service to requests. I would guess that most vouchers for SCP parks are plants and mammals, with fewer amphibians and reptiles, birds, and fishes. Typically, birds are badly under-represented in most collections from most areas. On the other hand, they (as well as diurnal mammals and amphibians and reptiles) can be documented by photographs (and should be as needed for confirmation). Our collection at MSB has good holdings of mammals, modest holdings of amphibians and reptiles from some parks, and historically important holdings of fishes from the Colorado River Basin although the fishes are not directly associated with parks in most instances. As a good faith effort in support of this I&M effort, we are willing to release all or portions of our database pending mutually-agreeable discussions.

5.2.3 Amphibians and Reptiles

At a minimum, presence of species at each park should be documented using high-quality, close-up color slides. Animals found dead and in identifiable condition should also be salvaged (e.g., those found dead on the road). Depending on park needs, live animals may also be collected and preserved as voucher specimens. This is particularly important when species are found at park units that are not expected, and/or range extensions.

Specimens found dead may be stored temporarily in a freezer at the Park or researcher's office. We suggest that specimens be put in a plastic bag (Zip-loc© heavy duty freezer bags are excellent), along with a piece of paper containing information on date of find, precise location where found, and collector. Air should be squeezed out of the bag, and the bag securely sealed. If the specimen will remain in the freezer for more than a few weeks, it is a good idea to double-bag the specimen. At the end of each year of sampling, all frozen specimens should be thawed out, injected with and immersed in 10% formalin for fixing, then transferred to 70% ethyl alcohol for preservation. Long-term storage should be in museum-quality glass storage jars. Animals collected alive may be killed by freezing or drowning in warm water, or preferably, through lethal injection of sodium pentobarbital (AVMA 1993). All specimens should be affixed with National Park Service issue specimen tags containing information on species, collector, date of collection, collection site, and NPS record number.

A potential negative side effect of any wildlife research project is injuring or stressing captured animals. Researchers may minimize stress by releasing animals as quickly as possible after capture. There is no reason to mark animals as part of the initial inventory work, but it is critical to the success of the future

monitoring phase of the I&M projects. Therefore, all animals captured during monitoring should be marked to assist with detection of long-term population trends, and to assess relative abundance and distribution of local reptiles and amphibians. Lizards may be toe-clipped (Ferner 1979); snakes may be scale-clipped (Ferner 1979); and amphibians may be freeze-branded (Donnelly et al. 1994). All of these methods will produce a mark that will be identifiable for at least several years, and none are thought to cause severe pain or long-term suffering to the animals. All procedures for handling the animals will be reviewed and approved by a University Institutional Animal Care and Use Committee (IACUC), and by each state's Game and Fish Department.

5.2.4 Vascular plants

For common, widespread, and easily identified species, unpublished or published checklists are acceptable. For all other species, a specimen in a park herbarium or regional herbarium is required. Selected species identifications will need to be verified by experts, especially for species in the genera *Astragalus, Carex, Chrysothamnus-Ericameria, Cirsium, Cryptantha, Erigeron, Eriogonum, Gilia, Penstemon, Phacelia, Phlox,* and *Poa*. Specimens will be prepared and curated as part of each flora project and entered into the NPSpecies database. At least one specimen of each species collected will be deposited in each unit that has a herbarium. Duplicate specimens and specimens for units that lack a herbarium will be deposited in a major regional herbarium, such as one of those at Utah State University, Brigham Young University (BYU), Northern Arizona University, or the University of New Mexico.

One important project will be initiated in the first year. This project will entail a plant taxonomist studying all material in park herbaria and verifying identifications. As part of this project, regional and major herbaria that are data-based will be searched for collections. Among these larger herbaria are: BYU, University of Utah (Garrett), Northern Arizona University (Deaver), University of Wyoming (Rocky Mountain), San Juan College, Utah State University (Intermountain), University of Colorado (Boulder), University of New Mexico, Southern Utah State University, Mesa College, and Ft. Lewis College. National herbaria include California Academy, Missouri Botanic Gardens, and New York Botanic Gardens. The description of this project can be found in Appendix F.

6. Individual Project Statements

6.1 Birds

6.1.1 Project Statement #1.
Priority 1: Clusters 1-3 Species Field Inventories

Problem Statement: The following park clusters have little or no information available on their bird species: cluster 1 (AZRU and YUHO); cluster 2 (HUTR); and cluster 3 (ELMO, PETR, SAPU). Species presence/absence has not been determined adequately for these parks. With such a lack of baseline information, the parks have no ability to develop management policies for the avian fauna, and also no knowledge of the occurrence of rare or sensitive species. These parks have the highest priority needs for avian fauna inventories.

Objectives: The overall goals of these inventories are to: 1) provide each park with a baseline inventory of breeding birds in major habitats within the park with the goal of documenting 90% of the species present; 2) identify park-specific species of special concern (which could become part of future "vital signs" monitoring); and 3), based on the inventory, to recommend an effective monitoring program so that Resource Management staff at each park can assess the condition of bird populations over time, and detect significant changes in those populations.

Parks: AZRU, YUHO, HUTR, ELMO, PETR, SAPU

Methods: Variable circular plot (VCP) surveys, area search surveys and tape playback surveys for nocturnal species will be conducted. During each visit, conduct at least one survey per habitat.

The methods and budgets for each cluster are based on the following assumptions. For Clusters 1-3, each park will be surveyed five times ("trips") per year, three during the breeding season and two during the non-breeding season. Each park will be surveyed for two years. Small parks, or those with limited habitat diversity, will require two days, one night at each park, assuming that two morning surveys can be conducted during each trip. Larger parks will require four days, three nights per park to ensure adequate sampling. Including travel time between parks, this will work out to five days per trip for the parks in Cluster 1 and 2, and 8 days per trip for Cluster 3. A two-person field crew will be adequate to conduct the research in Clusters 1, 2 and 3. Additionally, one day should be added to each trip for administrative work and data management. Logistically, Clusters 1, 2 and 3 will likely share a common project manager.

Schedule: (depending on each year's weather conditions):

1. Mid May to late May: First trip, 1 VCP and area search survey per habitat per day plus 1 nocturnal survey.
2. Early June to mid June: Second trip, 1 VCP and area search survey per habitat per day plus 1 nocturnal survey.
3. Mid June to early July: Third trip, 1 VCP and area search survey per habitat per day plus 1 nocturnal survey.

6.1.2 Project Statement #2.
Priority 2: Cluster 5 Species Field Inventories

Problem Statement: The following park (ELMA) has some limited information available on species presence/absence (Lightfoot et. al 1994), but due to its size and/or limited scope of previous research, will benefit from additional surveys. The poor state of knowledge of the avian fauna of this park, particularly the status of sensitive species, presently limits the park's ability to make informed management decisions.

Objectives: The overall goals of this inventory are to: 1) provide the park with additional surveys of birds stratified by major habitats within the Park, with the goal of rounding out knowledge of the avian fauna present (and documenting 90% of the species present); 2) identify park-specific species of special concern (which could become part of future "vital signs" monitoring); and 3) based on the inventory, to recommend an effective monitoring program so that Resource Management staff can assess the condition of the bird populations over time, and detect significant changes in those populations.

Park: ELMA

Methods: Variable Circular plot surveys, area search surveys and tape playback surveys for nocturnal species will be conducted. During each visit, at least one survey will be conducted per habitat.

The methods and budgets for this cluster are based on the following assumptions. For Cluster 5, the park will be surveyed five times ("trips") per year, three during the breeding season and two during the non-breeding season. Surveys will be conducted over two years. El Malpais has limited habitat diversity, and will require two days, one night, assuming that two morning surveys can be conducted during each trip. Taking travel time into account, this will work out to three days per trip. A one-person field crew will be adequate to conduct the research in Cluster 5. Additionally, one day should be added to each trip for administrative work and data management. Cluster 5 will have one project manager.

Schedule: (depending on each year's weather conditions):

1. Mid May to late May: First trip, 1 VCP and area search survey per habitat per day plus 1 nocturnal survey.
2. Early June to mid June: Second trip, 1 VCP and area search survey per habitat per day plus 1 nocturnal surveys.
3. Mid June to early July: Third trip, 1 VCP and area search survey per habitat per day plus 1 nocturnal survey.

6.2 Mammals

6.2.1 Project Statement #1.
Workshop on Science and Management of Large Carnivores in Colorado Plateau National Parks

Problem Statement: Large carnivores are a focus of management concern in many of the NPS units on the Colorado Plateau. Cougars (*Felis concolor*) and black bears (*Ursus americanus*) were identified as species of special interest in 11 and 5 parks, respectively, in a survey of the 36 Colorado Plateau NPS units. Of all mammals, cougars were mentioned most often. Although there is general curiosity about the status and life history of cougars and black bears, the impetus for special interest arose primarily from concerns for human safety. Cougars and black bears can frighten, injure, and kill humans (Herrero 1985,

Herrero and Fleck 1990, Beier 1991). A number of incidents have occurred in National Parks, including several on the Colorado Plateau. There is speculation that incidents may escalate with increased populations, especially of cougars.

While there has been significant research on cougars of the Colorado Plateau and other ecologically-similar regions (e.g., Robinette et al. 1959; Ackerman et al. 1984; Hemker et al. 1984; Lindzey et al. 1988, 1994; Anderson et al. 1992; Logan et al. 1996), little of this research has occurred in NPS units. Moreover, much research on cougars has focused on hunter harvest and livestock depredation – issues of little concern on most NPS lands. Research on black bears in NPS units on the Colorado Plateau has been limited to a survey in Mesa Verde NP (LeCount & Mollohan 1984). Otherwise, research has been restricted to surrounding mountains and highlands (Ogborn 1990, LeCount 1990, Beck 1991). General principles have been developed for management to minimize conflicts between humans and large carnivores (Herrero 1985, Logan & Sweanor 2000), but application of these principles requires site-specific information as well as compilation and full elucidation of the principles themselves. The need for information predictably increases in instances where managers try to harmonize potentially conflicting objectives, as in NPS units where there is regulatory requirement not only to protect humans, but also to preserve and protect native species such as cougars and black bears.

The extensive movements of large carnivores pose special problems for land managers. Cougars and black bears exist at comparatively low densities and occupy ranges of potentially large size. Most NPS units on the Colorado Plateau are smaller than the average life range of a cougar or black bear in this region (70-700 km^2 and 20-200 km2, respectively). Only a few (GRCA, GLCA, ZION, CANY, and CARE) are probably large enough to contain an appreciable number of cougars. Under these circumstances, management of cougar and bear populations on adjoining lands has major effects on these large carnivores and their interactions with humans in most parks. Managers increasingly recognize that interagency coordination is needed to adequately address a host of management issues. There is little doubt that a high level of such coordination will be required to deal with research and management issues related to large carnivores in NPS units on the Colorado Plateau.

Workshop: A 2-day workshop is planned for late Spring, 2000, to address management and research-needs pertaining to large carnivores on the Colorado Plateau. The location is yet to be determined, but will be chosen to facilitate travel by participants. The existence of suitable facilities also will be taken into consideration. The U.S.G.S. Colorado Plateau Field Station and Resource Management, Grand Canyon NP, will collaborate on planning and conducting the workshop.

Workshop goals & outcomes. --

1. Compile and present existing information on cougars and black bears in or near Colorado Plateau NPS units.

2. Compile and present information on relevant state and federal regulations, as well as local sociopolitical considerations relevant to the management of large carnivores.

3. Present existing strategies and other information pertaining to management of humans and large carnivores in park settings.

4. Articulate goals for large carnivore management as defined by existing federal and state regulations, as well as areas of potential common ground among those goals.

5. Formulate potential interagency strategies for managing cougars and black bears in and near Colorado Plateau parks to achieve common and jurisdiction-specific goals.

6. Identify research needs pertaining to large carnivores in and near NPS units and formulate a strategy for meeting these needs.

Workshop participants. -- Participants will include invited presenters and all interested NPS personnel, land managers from adjoining jurisdictions, state game managers with jurisdiction over wildlife in or near parks, and large carnivore scientists. Presenters will include those with experience in successfully managing cougars and bears in park settings as well as experts in the life histories of cougars and black bears.

Workshop structure. -- The first day will be devoted to presenting background information relevant to formulating management and research strategies, as per goals 1-3. The second day will be devoted to formulating those strategies, as per goals 4-6.

Workshop budget. -- A total of $12,000 will be allocated to conducting this workshop: $1,000 for refreshments, supplies, and rental of facilities; $11,000 to cover travel expenses. Of the $12,000, $6,000 will come from inventory money budgeted for the Northern Colorado Plateau Temperate Desert Group of parks. Most travel money will be used to defray the expenses of invited presenters. The remainder will be used to defray the expenses of NPS personnel unable to pay for travel out of other budgets. Priority will be given to personnel directly involved with management of wildlife in their respective parks.

6.2.2 Project Statement #2. Full baseline inventories for SCP Parks: Planning cluster 1 (AZRU, YUHO)

Problem Statement: Very little previous mammal work has been conducted on these parks (see Introduction for background information on each park) and neither has been the subject of a full baseline inventory. AZRU and YUHO, at 130 and 14 ha, respectively, are relatively small and should be relatively cost-effective to survey. AZRU needs a full survey and YUHO needs bat work. An Interagency Agreement has been signed with USGS to provide these surveys.

Objectives:

- Acquire all available historical data on status and occurrence of mammals at the parks, including copies of theses, dissertations, publications, reports, museum records of voucher specimens, and incorporate these data into a centralized database (Excel or Access);
- Assess occurrence for all mammals at these parks with the goal of documenting 90% of the potential species occurring at each park, retaining vouchers as necessary or appropriate;
- Conduct field studies using a combination of random and stratified-random plots, complete inventories (for small parks), special surveys for areas of particular importance (identified by park staff as possible), historic sites as needed, and intuitive sampling of areas deemed to be of high mammal species richness;
- Evaluate all sites for their potential for long-term monitoring;
- Provide a final report detailing the investigations at each park, accompanied by distribution maps (in ARCINFO format) of species occurrence at the parks, management recommendations as appropriate, and comments on status of sensitive species.

Study design and methods:

- Objective 1: The PI and staff will review available information at each park, request lists of voucher specimens from appropriate museums, review a master list of potential species at each park, and enter these data into a master file for each park.
- Objective 2: Using the master list approach, as refined by the PI, species will be documented through field inventories; photographs of animals, tracks, or scat; reliable reports of species observed by knowledgeable personnel; and species reported by other agencies (e.g., state fish and game departments).
- Objective 3: We will use complete inventories.
- Objective 4: All sites will be evaluated during field studies and subsequent analyses for their potential to serve as long-term monitoring sites because of their uniqueness in terms of species composition, endemism, or presence of sensitive species.
- Objective 5: The final report, one per park, will be produced in a mutually-agreed to format with all information (species captures/site, voucher specimens, georeferenced localities, distribution maps, etc.) attached as appendices to the final report.

Partnerships: This work will be conducted under an Interagency Agreement with the U.S. Geological Survey, Mid-continent Ecological Science Center, who will serve as a partner and contribute salaries of selected permanent staff, selected equipment, and some museum services as a cost share to the project.

Schedule: Survey work for mammals will be conducted primarily from May to September, depending in part upon elevation and climate at the park. For the most part, bats will be sampled during the summer months. Known, significant wintering aggregations of bats will be censused in the winter months as appropriate. Additional data collection from other sources (agency reports, etc.) will occur in the off-season. Planning assumes a four-person crew at each park.

Park	Complexity	Person-days/yr	Other Comments
AZRU	Low	28	Census possible; have funding
YUHO	Low	16	Bats only, have funding

Products: This project will generate documented occurrence of mammals on national parks with a goal of documenting up to 90% of mammal species on each park. Information will be contained in annual reports that report progress and problems to date, a final report in a mutually-agreed to format, Arcview GIS themes, and MS Excel or Access databases of all mutually-agreed to information as appendices to the final report. The NCP I&M Coordinator will oversee that project findings and data are placed or updated in the servicewide biological databases as appropriate. Metadata will be provided by the Principal Investigator. Final reports will be provided at mutually-agreed to dates that will allow NPS to use data in continued I&M efforts.

6.2.3 Project Statement #3. Full or partial baseline inventories for SCP Parks: Planning cluster 2 (HUTR and NAVA)

Problem Statement: In general, very little previous mammal work has been conducted on these parks (see Introduction for background information on each park) and none has been the subject of a full

baseline inventory. These parks are administered by the Navajo Nation which will execute the required work. NAVA is of moderate size and relatively complex. This park will have several different strata for sampling, and will present certain logistical problems. HUTR is much smaller in size and survey work will be relatively straightforward. Information is not sufficient to assess if there are selected species of local concern, although bats as a group are of concern, shrews are under-represented in most park work, and information on large mammals is frequently fragmentary and not well documented. Where specific concerns have been raised about sensitive species (e.g., big-eared bats), the baseline inventories will be designed to address these information needs.

Objectives:

- Acquire all available historical data on status and occurrence of mammals at the parks, including copies of theses, dissertations, publications, reports, museum records of voucher specimens, and incorporate these data into a centralized database (Excel or Access);
- Assess occurrence for all mammals at these parks with the goal of documenting 90% of the potential species occurring at each park, retaining vouchers as necessary or appropriate;
- Conduct field studies using a combination of random and stratified-random plots (for NAVA) complete inventories (for HUTR), special surveys for areas of particular importance (identified by park staff as possible), historic sites as needed, and intuitive sampling of areas deemed to be of high mammal species richness;
- Evaluate all sites for their potential for long-term monitoring;
- Provide a final report detailing the investigations at each park, accompanied by distribution maps (in ARCINFO format) of species occurrence at the parks, management recommendations as appropriate, and comments on status of sensitive species.

Study design and methods:

- Objective 1: The PI and staff will review available information at each park, request lists of voucher specimens from appropriate museums, review a master list of potential species at each park, and enter these data into a master file for each park.
- Objective 2: Using the master list approach, as refined by the PI, species will be documented through field inventories; photographs of animals, tracks, or scat; reliable reports of species observed by knowledgeable personnel; and species reported by other agencies (e.g., state fish and game departments).
- Objective 3: We will conduct a complete inventory of HUTR and sample randomly-selected grid points based on stratification of by elevation, aspect, etc for NAVA.
- Objective 4: All sites will be evaluated during field studies and subsequent analyses for their potential to serve as long-term monitoring sites because of their uniqueness in terms of species composition, endemism, or presence of sensitive species.
- Objective 5: The final report, one per park, will be produced in a mutually-agreed to format with all information (species captures/site, voucher specimens, georeferenced localities, distribution maps, etc.) attached as appendices to the final report.

Partnerships: This work will be conducted by the Navajo Nation. Other agencies and entities will be approached about their interest in contributing to the work, and individuals who have appropriate expertise and are known to individual parks may be contracted to some of the work. In all cases, known

or potential partners will be asked to contribute either funds or in-kind services that lead to the successful completion of this project.

Schedule: Survey work for mammals will be conducted primarily from May to September, depending in part upon elevation and climate at the park. Some "off-season" sampling of rodents, carnivores, and ungulates may occur; for the most part, bats will be sampled during the summer months. Known, significant wintering aggregations of bats will be censused in the winter months as appropriate. Additional data collection from other sources (agency reports, etc.) will occur in the off-season. Planning assumes a four-person crew at each park.

Park	Complexity	Person-days/yr	Other Comments
HUTR	Low	16	
NAVA	Mod. high	56	

Products: This project will generate documented occurrence of mammals on national parks with a goal of documenting up to 90% of mammal species on each park. Information will be contained in annual reports that report progress and problems to date, a final report in a mutually-agreed to format, Arcview GIS themes, and MS Excel or Access databases of all mutually-agreed to information as appendices to the final report. The NCP I&M Coordinator will oversee that project findings and data are placed or updated in the servicewide biological databases as appropriate. Metadata will be provided by the Principal Investigator. Final reports will be provided at mutually-agreed to dates that will allow NPS to use data in continued I&M efforts.

6.2.4 Project Statement #4. Full or partial baseline inventories for SCP Parks: Planning cluster 3 (ELMO, PETR, and SAPU)

Problem Statement: In general, very little previous mammal work has been conducted on these parks (see Introduction for background information on each park) and none has been the subject of a full baseline inventory. ELMO and SAPU need full surveys, and PETR needs a partial surveys, including the new land added to the park. Information is not sufficient to assess if there are selected species of local concern, although bats as a group are of concern, shrews are under-represented in most park work, and information on large mammals is frequently fragmentary and not well documented. Where specific concerns have been raised about sensitive species (e.g., big-eared bats), the baseline inventories will be designed to address these information needs.

Objectives:

- Acquire all available historical data on status and occurrence of mammals at the parks, including copies of theses, dissertations, publications, reports, museum records of voucher specimens, and incorporate these data into a centralized database (Excel or Access);
- Assess occurrence for all mammals at these parks with the goal of documenting 90% of the potential species occurring at each park, retaining vouchers as necessary or appropriate;
- Conduct field studies using a combination of random and stratified-random plots, complete inventories (for small parks), special surveys for areas of particular importance (identified by park staff as possible), historic sites as needed, and intuitive sampling of areas deemed to be of high mammal species richness;

- Evaluate all sites for their potential for long-term monitoring;
- Provide a final report detailing the investigations at each park, accompanied by distribution maps (in ARCINFO format) of species occurrence at the parks, management recommendations as appropriate, and comments on status of sensitive species.

Study design and methods:

- Objective 1: The PI and staff will review available information at each park, request lists of voucher specimens from appropriate museums, review a master list of potential species at each park, and enter these data into a master file for each park.
- Objective 2: Using the master list approach, as refined by the PI, species will be documented through field inventories; photographs of animals, tracks, or scat; reliable reports of species observed by knowledgeable personnel; and species reported by other agencies (e.g., state fish and game departments).
- Objective 3: Depending upon the size of the park, availability of data upon which park area can be stratified, and possibility of conducting mammal inventories at some of the same sites used by other vertebrate studies, we will use one of the following repeatable approaches at each park: complete inventories (small parks of a homogeneous nature), and randomly-selected study areas based on stratification of the park by elevation, aspect, etc.
- Objective 4: All sites will be evaluated during field studies and subsequent analyses for their potential to serve as long-term monitoring sites because of their uniqueness in terms of species composition, endemism, or presence of sensitive species.
- Objective 5: The final report, one per park, will be produced in a mutually-agreed to format with all information (species captures/site, voucher specimens, georeferenced localities, distribution maps, etc.) attached as appendices to the final report.

Partnerships: This work will be conducted under an Interagency Agreement with the U.S. Geological Survey, Mid-continent Ecological Science Center, who will serve as a partner and contribute salaries of selected permanent staff, selected equipment, and some museum services as a cost share to the project. In addition, other agencies and entities will be approached about their interest in contributing to the work, and individuals who have appropriate expertise and are known to individual parks may be contracted to work at some parks. In all cases, known or potential partners will be asked to contribute either funds or in-kind services that lead to the successful completion of this project.

Schedule: Survey work for mammals will be conducted primarily from May to September, depending in part upon elevation and climate at the park. Some of these parks may lend themselves to some "off-season" sampling of rodents, carnivores, and ungulates; for the most part, bats will be sampled during the summer months. Known, significant wintering aggregations of bats will be censused in the winter months as appropriate. Additional data collection from other sources (agency reports, etc.) will occur in the off-season. Smaller parks will require fewer person-days of work, larger more complex parks will require more time; times are estimates in all cases. Planning assumes a three-person crew at each park. Two of the parks (PETR and SAPU) will be done as a unit due to their geographic proximity and to reduce costs.

Park	Complexity	Person-days/yr	Other Comments
ELMO	Mod. low	56	Full baseline needed
PETR	Moderate	56	Urban, new lands need work
SAPU	Mod. high	56	Dispersed units, full baseline

Products: This project will generate documented occurrence of mammals on national parks with a goal of documenting up to 90% of mammal species on each park. Information will be contained in annual reports that report progress and problems to date, a final report in a mutually-agreed to format, Arcview GIS themes, and MS Excel or Access databases of all mutually-agreed to information as appendices to the final report. The NCP I&M Coordinator will oversee that project findings and data are placed or updated in the servicewide biological databases as appropriate. Metadata will be provided by the Principal Investigator. Final reports will be provided at mutually-agreed to dates that will allow NPS to use data in continued I&M efforts.

6.2.5 Project Statement #5. Focused inventories for selected SCP Parks Planning Cluster 5-6 (BAND, CHCU, ELMA)

Problem Statement: In the Southern Colorado Plateau network in New Mexico there are three parks that have had some level of previous survey and that now require completion of those surveys or focused surveys on particular groups of mammals, as decided by participants at the May meeting in Moab. These parks have varying levels of previous surveys: ELMA has some previous coverage but lacks details in some habitats and groups; BAND has a spotty previous survey (1970s) and recent data on bats but needs surveys on most other groups, and CHCU needs work on lagomorphs, rodents, and carnivores (see Introduction for background information on each park). These three parks are relatively large and complex and BAND in particular will be logistically challenging with ELMA somewhat less so. Information is not sufficient to assess if there are selected species of local concern, although bats as a group are of concern, shrews are under-represented in most park work, and information on large mammals is frequently fragmentary and not well documented. Where specific needs on sensitive species have been raised (e.g., some bat species), those concerns will be addressed as a part of the focused inventories.

Objectives:

- Acquire all available historical data on status and occurrence of mammals at eight parks, including copies of theses, dissertations, publications, reports, museum records of voucher specimens, and incorporate these data into a centralized database (Excel or Access);
- Assess occurrence for all mammals at these parks with the goal of documenting 90% of the potential species (master list) occurring at each park, retaining vouchers as necessary or appropriate;
- Conduct field studies using a combination of random and stratified-random plots, complete censuses (for small parks), surveys in areas of special importance (identified by park staff as possible), historic sites as needed, and intuitive sampling of areas deemed to be of high mammal species richness;
- Evaluate all sites for their potential for long-term monitoring;
- Provide a final report detailing the investigations at each park, accompanied by distribution maps (in ARCINFO format) of species occurrence at the parks, management recommendations as appropriate, and comments on status of sensitive species.

Study Design And Methods:

- Objective 1: The PI and staff will review available information at each park, request lists of voucher specimens from appropriate museums, review a master list of potential species at each park, and enter these data into a master file for each park.
- Objective 2: Using the master list approach, as refined by the PI, species will be documented through field inventories; photographs of animals, tracks, or scat; reliable reports of species observed by knowledgeable personnel; and species reported by other agencies (e.g., state fish and game departments).
- Objective 3: Depending upon the size of the park, availability of data upon which park area can be stratified, and possibility of conducting mammal inventories at some of the same sites used by other vertebrate studies, we will use one of the following repeatable approaches at each park: complete inventories (small parks of a homogeneous nature) and randomly-selected study areas based on stratification of the park by elevation, aspect, etc.
- Objective 4: All sites will be evaluated during field studies and subsequent analyses for their potential to serve as long-term monitoring sites because of their uniqueness in terms of species composition, endemism, or presence of sensitive species.
- Objective 5: The final report, one per park, will be produced in a mutually-agreed to format with all information (species captures/site, voucher specimens, georeferenced localities, distribution maps, etc.) attached as appendices to the final report.

Partnerships: Some of this work will be conducted under an Interagency Agreement with the U.S. Geological Survey, Mid-continent Ecological Science Center, who will serve as a partner and contribute staff time, selected equipment, and some museum services as a cost share to the project. Likewise, the Colorado Plateau Field Station of the USGS Forest and Rangeland Ecological Science Center will conduct some of the work and contribute staff services and equipment. We will seek cooperation from other government agencies and private entities in contributing to the work. In addition, other cooperators who have appropriate expertise and are known to individual parks may be contracted to work at some parks. In all cases, known or potential partners will be asked to contribute either funds or in-kind services toward the project.

Schedule: Survey work for mammals will be conducted primarily from May to September, depending in part upon elevation and climate at the park. Some parks may lend themselves to some "off-season" sampling of rodents, carnivores, and ungulates; for the most part, bats will be sampled during the summer months. Known, significant wintering aggregations of bats will be censused in the winter months as appropriate. Additional data collection from other sources (agency reports, etc.) will occur in the off-season. Smaller parks will require fewer person-days of work, larger more complex parks will require more time; times are estimates in all cases. Planning assumes a three-person crew at all parks. These parks (BAND, CHCU, and ELMA) are relatively close in New Mexico and will be surveyed sequentially to reduce costs. Comments on remoteness refer to logistical access.

Park	Complexity	Person-days/yr	Other Comments
BAND	High	84	Stratification needed, remote
CHCU	Moderate	56	Mod. remote
ELMA	Mod. high	84	Remote, access difficult

Products: This project will determine occurrence of mammals on national parks with a goal of documenting up to 90% of mammal species on each park. Information will be contained in annual reports that report progress and problems to date, a final report in a mutually-agreed-to format, Arcview GIS themes, and MS Excel or Access databases of all mutually-agreed-to information as appendices to the final report. The NCP I&M Coordinator will oversee that project findings and data are placed or updated in the servicewide biological databases as appropriate. Metadata will be provided by the Principal Investigator. Final reports will be provided at mutually-agreed-to dates so that NPS will have access to the data for continued planning.

6.3 Amphibians and Reptiles

6.3.1 Project Statement #1. Priority 1: Clusters 1-4 Species Field Inventories

Problem Statement: The following park clusters have little or no information available on their reptile and amphibian species: 1 (AZRU and YUHO); 2 (CACH, HUTR, and NAVA); 3 (ELMO, PETR, and SAPU) and 4 (SUCR, WACA, and WUPA). Species presence/absence has not been determined adequately for most of these parks. With such a lack of baseline information, the parks have no ability to develop management policies for the herpetofauna, and also no knowledge of the occurrence of rare or sensitive species. These parks have the highest priority needs for herpetofauna inventories.

Objectives: The overall goals of these inventories are to: 1) provide each park with a baseline inventory of reptiles and amphibian in major habitats within the Park with the goal of documenting 90% of the species present; 2) identify park-specific species of special concern (which could become part of future "vital signs" monitoring); and 3) based on the inventory, to recommend an effective monitoring program so that Resource Management staff at each park can assess the condition of amphibian and reptile populations over time, and detect significant changes in those populations.

Parks: AZRU, CACH, ELMO, HUTR, NAVA, PETR, SAPU, SUCR, WACA, WUPA, YUHO

Methods: TCS, road driving, and amphibian surveys. During each visit, conduct at least one TCS per habitat, and road drive every night while in the park. One amphibian survey should be conducted at each permanent and semi-permanent body of water in the park per trip during the spring and monsoon trips.

The methods and budgets for each cluster are based on the following assumptions. For Clusters 1-4, each park will be surveyed three times ("trips") per year, and the sampling period will last two years. Small parks, or those with limited habitat diversity, will require two days, one night at each park, assuming that two morning surveys (during peak reptile activity) can be conducted during each trip. Larger parks will require four days, three nights per park to ensure adequate sampling. Taking travel time between parks into consideration, this works out to five days per trip for the parks in Cluster 1, and ten days per trip for Clusters 2, 3, and 4. While a two-person field crew will be adequate to conduct the research in Clusters 1, 3, and 4, we recommend a three-person crew for Cluster 2 to cover the relatively larger CACH and remoter sections of NAVA. Additionally, one day should be added to each trip for administrative work and data management. Logistically, Clusters 1 and 3 will share a common project manager, as will Clusters 2 and 4.

Schedule: (depending on each year's weather conditions):

1. early-May to early June: First trip, 1 TCS/habitat/day and amphibian searches
2. early-mid July: Second trip, 1 TCS/habitat/day + road driving at night + amphibian searches
3. mid-late August: Third trip, 1 TCS/habitat/day + road driving at night

6.3.2 Project Statement #2.
Priority 2: Clusters 5-7 Species Field Inventories

Problem Statement: Four larger parks (and one small park) have some limited information available on species presence/absence (e.g., Jones 1970), but due to their size and/or limited scope of previous research, will benefit from additional surveys. These include Clusters 5 (BAND, CHCU), 6 (ELMA), and 7 (GLCA and RABR). The poor state of knowledge of the herpetofauna of these parks, particularly the status of sensitive species, presently limits the ability of the parks to make informed management decisions.

Objectives: The overall goals of these inventories are to: 1) provide each park with additional surveys of reptiles and amphibian stratified by major habitats within the Park, with the goal of rounding out knowledge of the herpetofauna present (and documenting 90% of the species present); 2) identify park-specific species of special concern (which could become part of future "vital signs" monitoring); and 3) based on the inventory, to recommend an effective monitoring program so that Resource Management staff at each park can assess the condition of amphibian and reptile populations over time, and detect significant changes in those populations.

Parks: BAND, CHCU, ELMA, GLCA, RABR

Methods: TCS, night driving, and amphibian surveys. During each visit, conduct at least one TCS per habitat using a stratified random sampling framework (see Section 9), and road drive every night while in the park. One amphibian survey should be conducted at each permanent and semi-permanent body of water in the park per trip during the spring and monsoon trips.

Clusters 5 and 6 contain the largest parks in the SCP region. Thus, we recommend that a four-person crew sample each park over two years, at four visits per park per year. Each trip to a park should last four days, three nights, or (with travel) 10-day long trips to each cluster. Additionally, one day should be added to each trip for administrative work and data management.

Schedule: (depending on each year's weather conditions):

1. early May to early June: First trip, 1 TCS/habitat/day + amphibian surveys
2. early-mid July: Second trip, 1 TCS/habitat/day + night driving + amphibian surveys
3. early-mid August: Third trip, 1 TCS/habitat/day + night driving + amphibian surveys
4. early-mid September: Fourth trip, 1 TCS/habitat/day + road driving at night

6.4 Vascular plants

6.4.1 Project Statement #1.
Priority 1: Clusters 1 and 3 Plant Species Field Inventories

Problem Statement: AZRU, YUHO (Cluster 1), and ELMO, PETR (Cluster 3) all need basic plant inventories. AZRU has had a survey for special status plants and several partial surveys of the monument. YUHO has had several surveys and compilation of vegetation types. However, there is still a need for basic biological inventories at these parks that will serve as a baseline for monitoring and for planning park projects.

Objectives: The principal objectives for the plant inventories are to document the occurrence of 90% of plant species, survey for special status species, and to provide baseline information for park planning and future natural resource monitoring.

Methods: Visits to the monuments within clusters will be coordinated to use travel funds most economically. Parks will be visited twice each growing season, once in the early part of the summer, and once later in the summer after the beginning of the summer monsoons. The purpose of the two visits is to capture plant species adapted to two peaks of moisture – early, if there has been a cool, moist late-winter and early spring, and late, after the more predictable late summer precipitation has begun. This will maximize the potential for seeing and identifying plant species. If necessary, one of the trips will encompass the blooming time of special status plants to increase the likelihood of encountering and recognizing these species.

At AZRU, ELMO, and PETR, sampling points generated by stratification and/or random grid selection will be located on the ground. One hectare plots or Whittaker plots will be established near the sampling points, with a corner located at a randomly selected point along a 50 m tape. The tape will be placed along a randomly selected compass heading. If the one hectare and relevé plots are used, all plant species within the one hectare plot will be recorded (Davis and Halvorson 2000). One or more relevé plots will be placed within the larger plot. Following CPVAC or similar technique, species composition and abundance will be recorded. If Whittaker plots are used, species composition and cover will be recorded from subplots and the larger plot. YUHO is the smallest in area (14 ha), and stratification may not be necessary or appropriate. Sampling plots will be located with a simple grid overlying the entire monument. At all sites, species cover data will be collected once, during the late summer visit.

Schedule: (Dependent on weather conditions and special status species blooming times)

1. May through June – First visit, locate and mark sampling points, establish plots, survey plots intensively for plant species, survey surrounding areas for plant species.

2. Late July through early September – Second visit, survey one hectare plots intensively for plant species, collect data on species composition and cover from smaller plots, survey surrounding area for plant species.

6.4.2 Project Statement #2
Priority 1: Cluster 2 Species Field Inventories

Problem Statement: Due to the paucity of information of plants, baseline plant inventories are first priority for Canyon de Chelly National Monument and Hubbell Trading Post National Historic Site (Gandhi et al. 1987, Halse 1973, Harlan et al. 1976). Canyon de Chelly has many sensitive habitats (hanging gardens, seeps and springs, and relic plant communities) that need to be surveyed. Baseline inventory is also needed for Inscription House (Navajo National Monument). Betatakin Ruin and Keet Seel are in need of exotic and special status plant inventories. Existing information will be used and included whenever possible (Drost 2000, Gandhi et. al. 1987, Holiday 1998).

Objectives: For Navajo NM (Inscription House) and Hubbell TP baseline inventories will be accomplished by performing complete area searches within the park boundaries.

Because of the size and access difficulty at Canyon de Chelly, as well as the presence of sensitive habitats, a complete inventory will not be possible in two years. However, it is likely that 90% of the plants present can be located by collecting in all major side canyons and tributaries as well as canyon rims

twice during the first year (May-June, August-September 2001). This will be accomplished by walking (and driving where possible) the area, taking detailed notes on species present and collecting vouchers of all species encountered. Points of access to different habitat types will also be documented for use in the second year of the study.

A special focus during the baseline inventories will be on sensitive habitats (hanging gardens, seeps and springs, and relic stands of vegetation), because they often contain a significant number of species not found anywhere else. For sensitive species encountered the standard protocol used by the Natural Heritage Program (Element Occurrence Form) will be utilized. Exotic species will be recorded according to the protocol of the Southwest Exotic Plant Mapping Program (SWEMP 1999).

Methods: One hectare plots and sample plots to establish species density, cover, relative abundance and richness will be established during the first year if possible, however, the difficulty of access at Canyon de Chelly may preclude the establishment of plots until the second year. In the second year of study, the one hectare and relevé plots will be established using the grid based sampling system.

During the third year of study, the second set of sampling points will be established and the information gathered during the first two years of study will be utilized to determine the location and set-up of long term monitoring plots for sensitive & exotic species as well as special habitats.

Voucher specimens will be collected when necessary and appropriate and the location of the collection will be recorded using a Global Positioning System. T&E species encountered will be mapped using a GPS, and vouchers will be collected. All voucher specimens will be deposited at the NPS herbaria where available and duplicate specimens will be deposited at the NAU Deaver Herbarium and the Navajo Herbarium at the Department of Fish & Wildlife. A field report on sensitive species will include a map, habitat description, elevation, site condition, threats apparent, and vegetation type based on the Spence-Romme-Floyd-Hanna-Rowlands classification system for the southern Colorado Plateau. Special habitats will be measured, delineated, and inventoried for all species present. Species cover will be recorded using relevé plots. Exotic species will recorded according to the SWEMP protocol, including estimated area, cover percentage, density, and additional site-specific information.

Schedule: (depending on each year's weather conditions)

1. May to June: First trip of year, searching for early blooming perennials and annuals (in seeps and springs, sedges, bulrushes, etc.). In first year if possible, and second year if not, locate points and establish one hectare plots, and take data on species present.

2. August to September: Second trip of year, searching for species responding to summer rainfall. In first year if possible, take data from one hectare plots, and place relevé plots to collect information on plant species composition and abundance.

6.4.3 Project Statement #3.
Priority 2: Cluster 7 Species Field Inventories

Problem Statement: GLCA is the largest unit in the Southern Colorado Plateau Network. Because of its size, significant areas remain under-surveyed for flora. Some of the more important areas include the Kaiparowits Plateau and adjacent benches, the San Juan River Basin, and Cataract Canyon-Dark Canyon region. The park checklist (Spence and Zimmerman 1996) lists 785 species, as well as an additional 100 species that occur in adjacent areas and are likely to be found with additional fieldwork. The checklist is based primarily on Atwood et al. (1979), Neese (1981), Welsh (1984), Schultz et al. (1987), and

additional unpublished collections made since 1992. The species-area curve developed for plants (see section 4) suggests that the flora of GLCA should consist of ca. 900 species.

Objectives: The overall goals of this inventory are to: 1) complete inventories on the flora of GLCA through additional fieldwork in selected areas, representing ca. 100,000 hectares, and documenting through species-estimation the master checklist techniques whether the 90% completeness goal has been reached, 2) collect additional vegetation data from the sampling points using the CPVAC relevé method, 3) document the presence of any new special status and exotic plant species to the NRA, 4) determine areas of GLCA that may be suitable for long-term monitoring of significant vegetation types or floristically rich areas.

Park: GLCA

Methods: The primary inventory method will be the establishment of a sampling grid for areas of the park to be surveyed (see section 4), with a random start and selection of a number of points based on the knowledge and judgement of the GLCA botanist. At each selected point, area searches in each distinct type of community present will be surveyed, CPVAC relevés read, and voucher specimens of all but the most widespread and common species made. At the end of the first field season, species-area curves will be analyzed to determine how much additional effort is needed in year 2 and how close the overall goal of 90% has been approached. A master checklist will be compiled for the flora of the region. The field crew will consist of a two-member team, comprising the park botanist and GS-07 botanist. Two years is needed because of extreme variation in precipitation patterns in the region (Spence 2000). If surveys were done in a drought year a significant portion of the annual flora would be missed. Because of the sampling framework, it is anticipated that many sample points will be remote and difficult to access. The budget includes 12 hours/year of helicopter time to access remote points.

Schedule: (depending on each year's weather conditions): Fieldwork will commence in April of each year, and will consist of two seasons, April-June, and August-September.

Budget: see attached Table.

6.4.4 Project Statement #4.
Priority 2: Clusters 4, 5, 8 and 9 Special Status Species Inventories

Problem Statement: Five parks in four clusters require inventory work on the status and abundance of special status native plant species, BAND, CHCU, GRCA, MEVE, and WUPA.

Objectives: The overall goals of this inventory are to: 1) complete inventories on the special status species listed in Table 7; 2) collect data on abundance, status and ecology for selected populations of these species; and 3) provide recommendations for long-term monitoring.

Parks: BAND, CHCU, GRCA, MEVE, WUPA.

Table 7. Special status native plant species, by park.

Species	BAND	CHCU	GRCA	MEVE	WUPA
Aletes macdougalii ssp. *radiatus*		X			
Amsonia peeblesii					X
Arctomecon californica			X		
Argemone arizonica			X		
Astragalus cotamii		X			
Astragalus cremnophylax			X		
Astragalus lentiginous var. *ambiguus*					X
Astragalus naturitensis		X			
Astragalus oocalycis		X			
Botrychium multifidum	X				
Camissonia specuicola ssp. *hesperia*					X
C. specuicola ssp. *specuicola*		X	X		
Cheilanthes feei				X	
Clematis pseudoalpina				X	
Cymopterus megacephalus					X
Cypripedium calceolus var. *pubescens*	X				
Cystopteris fragilis				X	
Errazurizia rotundata					X
Fritillaria atropurpurea				X	
Holodiscus dumosus				X	
Iliamna rivularis				X	
Lilium umbellatum	X				
Pediocactus peeblesianus var. *fickeiseniae*					X
Pediocactus simpsonii					X
Phacelia serrata					X
Phacelia welshii					X
Psorothamnus thompsoniae var. *whitingii*					X
Puccinellia parishii					X
Rosa stellata var. *abyssa*			X		
Silene rectiramea			X		
Talinum validulum			X		
Viola adunca				X	
V. nuttallii				X	
Woodsia oregana				X	

Methods: Methods will vary depending on each species. For small areas or species with specific and well-known habitat preferences, all areas will be searched. For larger parks, potential habitat will be identified using GIS mapping and selection of sampling points, stratified by habitat, geology, or other important variables.

Schedule: Will vary depending on the biology of each species. Methods can be found in Elzinga et al. (1998).

6.4.5 Project Statement #5
Priority 2: Cluster 5 (CHCU) Exotic plant species studies

Problem statement: The invasion of non-native species, including plants, has become of world-wide concern. Exotic species have been found to effect ecosystem processes and in some cases to compete with and sometimes exclude native species. (Mack 1989, Vitousek 1992, Howe and Knopf 1991, Christian and Wilson 1999). In some cases, invasion may contribute to the overall biodiversity of an area by adding species to those already present, although with unknown or poorly understood effects on ecosystem function (Pimm 1991, Parker et al. 1999).

In North America, many national parks and monuments have been invaded by exotic plant species to some degree (Hiebert 1997). Non-native or exotic plant species have invaded disturbed areas and some native communities in most parks and monuments on the Southern Colorado Plateau. At Chaco Canyon and outlying areas, tamarisk (*Tamarix pentandra*) has invaded riparian areas, and annual brome grasses (*Bromus tectorum*, *B. japonicus*, and others) have become abundant in shrub-grasslands. Tamarisk is well known for its ability to colonize recently disturbed areas along permanent or intermittent streams, and native riparian species are often unable to compete (Howe and Knopf 1991). Annual bromes may affect both native annual and perennial plant species, as well as ecosystem processes (Mack 1989). There may be other exotic species occurring at the park, especially in areas that have been recently acquired and that have not received as much attention as the older parts of the park. Effective management of exotic species includes detection of their presence, elimination of them if desirable and possible, and prevention of their spread. In order to manage effectively, accurate knowledge about the distribution and abundance of exotic species is required. This project will assist the staff at Chaco Culture NHP by documenting the presence of exotic species in the park, and by mapping the distribution of species that are known to occur and that have the potential for further spread and alteration of ecosystem processes. In addition, methods developed by Hiebert and Stubbendiek (1993) will be used to establish priorities for further study and to make decisions about control.

Objectives: The objectives of this project are to 1) document the presence of non-native plant species at Chaco Culture NHP by review of species lists and vegetation sampling data; 2) to survey the park for previously undocumented species; 3) assist the park staff in setting priorities for additional work, including control priorities; 4) map the distribution of tamarisk (in areas away from the main channel of Chaco Wash) and annual bromes (or other species that may receive higher priority).

Methods Species lists for Chaco Culture NHP and data from vegetation sampling will be reviewed for non-native species. Surveys of selected habitats will be conducted, including those most likely to be the sites of introductions of non-native species, like roadsides, construction areas, campgrounds, and other disturbed areas. Recently acquired areas of the park will receive special attention. The distribution of tamarisk away from the main channel of the Chaco Wash (which is being mapped in another project) will be mapped using GPS technology. Review of species lists and survey may result in priorities for mapping other species as well.

Schedule: Timing visits to the parks will depend on the species selected for study, and on the weather conditions for the year.

1. Late-April – June for early species (e.g. *Bromus* sp.)
2. Late-July – September, for later species (e.g. *Halogeton*, *Kochia, Melilotus*)

Funding: FY 2001 Amount Requested: $5,000

6.4.6 Project statement #6
Priority 2: Cluster 8 (GRCA) Exotic plant species studies

Problem Statement: One of the top natural resource priorities for the NPS nationwide is the control of exotic plant species (NPS 1995, Executive Order No. 13112, February 3, 1999). The invasion and spread of exotic plants is one of the most serious threats to the survival of natural communities and processes that the National Park Service (NPS) is mandated to protect (USDI 1988, Heywood 1989, Coblentz 1990, U.S. Congress 1993, Cronk and Fuller 1995, Randall 1996, USDI 1996). Exotic plant species displace native species, reduce species richness, damage historic and archeological resources, and interfere with natural ecosystem processes (Macdonald 1983, Breytenback 1986, Henderson and Wells 1986, USDI 1988, Soulé 1990, Randall 1996). The NPS defines exotic species as those species that are non-indigenous to an area and occur as a result of direct, indirect, deliberate or accidental human actions (USDI 1988). These species have not evolved with the native species and would not be a component of the ecological system without human intervention (USDI 1988, Temple 1990).

NPS management policies require managers "to maintain all the components and processes of a natural evolving park ecosystem including the natural abundance, diversity and ecological integrity of plants and animals" (USDI 1988). Park managers are directed to give high priority to the control and management of exotic species that can be easily managed and have substantial impacts on the Park's resources (USDI 1985, USDI 1988). Grand Canyon National Park (GCNP) recently completed Phase I of an Exotic Plant Species Management Plan (EPSMP). A system designed to categorize exotic plant species based on their present level of impact, their innate ability to become a pest, and the feasibility of control or management was used to prioritize future management actions (Hiebert and Stubbendieck 1993). The majority of the exotic plant species found in the park (132 out of 145) were included in the ranking system. The remaining 13 species were not included in the ranking system until positive verification and documentation is completed. The results from the ranking process determined which species can be easily controlled and have substantial impact on the Park's resources (i.e. those species that managers are directed to give high priority to the control and management of).

The majority of the species area and distribution data that was included in the ranking system was based on the Annotated Checklist of Vascular Plants (Phillips et al. 1987), which is outdated. For some species and for the more recent arrivals, there is no distribution data. In addition, several new species have been identified within the park, but the actual extent of the species is not known. This survey and mapping work will provide the park with data that will help ensure that the highest priority species are managed for.

Objectives: The overall objectives of these inventories are to: 1) provide park managers with a baseline inventory of exotic plant species in the Desert View area, the South Rim Village, the North Rim Village, and along the corridor trails; 2) map populations of high priority exotic species and share the mapping information with the Southwest Exotic Mapping Program, United States Geologic Survey, Biological Resources Division; 3) install long term monitoring transects near the park entrances at Desert View and the South Entrance.

Methods: Due to limited funding, only a few long term monitoring transects will be installed. Line transects will be installed, 50m in length, and the point intercept method will be used to determine species cover. The placement of these transects will be determined based on the survey information obtained. Park boundaries and entrances may be a good location to monitor the spread of new species into the park.

Schedule:

1. April 15 – April 28: Survey and map Bright Angel Trail, South Kaibab Trail, North Kaibab Trail, Phantom Ranch and Indian Garden.
2. April 29 – May 12: Survey and map the South Rim Village area (including the roadsides along east and west rim drive if time allows)
3. May 13 – May 19: Survey and map the Desert View area
4. May 20 – June 23: Finish any South Rim Village / West Rim Drive mapping.
5. June 24 – July 7: Survey and map the North Rim Village area
6. July 8 – August 18: Map additional trails and disturbed areas as time allows, install transects, compile all the data into the SWEMP format, get all data sheets and GPS files to SWEMP, complete final maps.

Summary of Budget Request: A total of $10,000 is available for this exotic plant species' survey and mapping project. This project cost will be used for the salary of a GS-06 Biological Technician, per diem, and the remaining money will be used for miscellaneous supplies to support this project. This technician will be responsible for all of the above listed surveying and mapping. A vehicle for use during the season will supplied by the park. The park will also provide the GPS unit, computer, GIS software, and other equipment.

6.4.7 Project statement #7
Priority 2: All park units, National Park and Regional Herbaria Searches

Project Statement: The National Park Service has initiated an effort to catalog the presence of all vascular plant taxa occurring within parks in the National Park Species (NPSpecies) database. Voucher specimens residing in a variety of institutional herbaria represent a significant information resource on the occurrence and distribution of plant species within individual National Parks. Specimen information from these herbaria is not readily accessible or useable for a variety of reasons including misidentification of specimens, uncertain location information, outdated nomenclature and inaccessibility of data.

Herbaria are located at individual National Parks as well as regional and national universities and museums. 10 of the 19 NCPN parks have herbaria (Table, below). Although some individual national parks maintain an automated database (ANCS+) for biological and cultural collections, this data is not always complete, and nomenclature may be out of date. In addition, specimens may be in need of curation. For example, the herbarium at CHCU includes only unmounted specimens still in newspaper.

Table: Number of Specimens in National Park Herbaria within the Southern Colorado Plateau Network.

AZRU		NAVA	100
BAND	2200	PEFO	700
CACH		PETR	134
CHCU	200	RABR	see GLCA
ELMA		SAPU	
ELMO		SUCR	See WUPA
GLCA	1300	WACA	471
GRCA	8000	WUPA	626
HUTR	No herbarium	YUHO	See MEVE
MEVE	2780		

Due to restrictive NPS collections management polices many regional institutions (e.g. universities) have declined to actively curate collections from the parks. As a result communication between regional (and national) herbaria and national parks within the network has been poor. We suspect that collections at these regional institutions contain many plant specimens from network parks and we propose to conduct electronic and manual herbarium searches at these institutions. Searches of regional collections would be coordinated and cost-shared with adjacent networks such as the Northern Colorado Plateau Network.

We propose to do a variety of herbaria searches to obtain voucher information, as well as verifying identifications in collections held by individual parks in the network. This information will be used to update ANCS+ and NPSpecies databases. In addition, location data will be added to network inventory databases.

OBJECTIVES:

1. Conduct an expert review and annotation of all National Park herbaria within the SCPN.
2. Initiate an electronic data search of important regional and national herbaria for specimens occurring within SCPN parks.
3. Review results of electronic data searches and select herbaria for manual searches to complete gaps in knowledge.
4. Seek partnerships with herbaria undergoing data computerization to speed up the location and computerization of records of specimens from national parks
5. Review results of manual and electronic searches and revise species names to reflect current taxonomy.
6. Work with NCP inventory and monitoring personnel to coordinate the collection of information from herbaria to ensure compatibility of data and eliminate duplication of effort.
7. Provide revised herbarium species lists and distribution information (in the form of NPS data bases and other useful formats) to principal investigators working on plant inventories as well as NPS at park and national levels.

Methods and approach:

To meet objective 1 we plan on contracting expert botanical expertise to conduct on-site studies of material in herbarium collections of 10 parks, in order to verify identifications. We anticipate a National Park Service employee working side by side with the expert(s) recording annotation information as the collections are reviewed. To ensure that these corrections are incorporated into the ANCS+ database, we will work directly from a print-out of current ANCS+ plant data. Corrections will be manually entered into ANCS+ and NPSpecies databases. We intend to initiate a portion of the herbarium review work in the first year of this project. Five parks will be visited the first year, and five the second year, of this project.

Regional and national herbaria are a potential significant source of plant voucher information for the network. Among these larger herbaria are: Brigham Young University (BRY); University of Utah (Garrett); Northern Arizona University (Deaver); University of Wyoming (Rocky Mountain); San Juan College; Utah State University (Intermountain); University of Colorado (Boulder); University of New Mexico; Southern Utah State University; Mesa College; and Ft. Lewis College. National herbaria include California Academy, Missouri Botanic Gardens, and New York Botanic Gardens.

For objective 2 we need to identify which institutional herbaria have specimen data in electronic formats. In year one we plan on initiating some level of data acquisition from these institutions. We are uncertain of the costs associated with obtaining this electronic data. We plan on coordinating and cost-sharing this work with the Northern Colorado Plateau Network vegetation group. Since the needs and costs of a project like this are not known, we anticipate that meeting this objective may require the assistance of a data manager.

Objective 3 will require site visits to selected regional herbaria to manually obtain voucher specimen information where electronic data is not available, or there is a need to view the specimens directly. This work would be conducted by trained botanical NPS staff or expert botanical contractors.

Objective 4 will require working with herbaria undergoing computerization of their collections to make NPS specimens a priority for location and entering into a data base. This may require the assistance of a data management expert to assist in the collection and transfer of data in compatible formats. Objectives 5, 6, and 7 will entail continued cooperation and coordination with other aspects of the inventory program within the SCP parks and with the NCP program

Partnerships:

Portions of this project targeting acquisition of voucher data from regional and national institutions will be conducted jointly with the Northern Colorado Plateau Network vegetation group. It is possible that other adjacent networks may be interested in a combined effort. Our intention is to cost-share this work where possible. There are also potential partner ships with regional herbaria.

Products:

This project will generate updated presence/absence lists and distribution maps for plant species within Southern Colorado Plateau parks. The identification of all park herbarium collections will be verified and annotated accordingly. These corrections and updates will be incorporated into ANCS+ and NPSpecies databases. This information will also be included in park inventories. Investigators working on inventory and monitoring will be provided with updated information from herbaria to use in their studies of species presence and distribution.

Implementation:

This project will be coordinated by the SCPN Inventory and Monitoring Program Manager. The work will be conducted through a combination of contract and in-house work. We will seek the best expert botanical assistance available for the verification of park plant collections. For data management needs, we will use in-house personnel when possible, but it may be necessary to have additional assistance.

Funding:

At this time we do not have enough funding to complete all of the work associated with this project. We plan on seeking additional funding through other NPS regional and national competitions. The current inventory funding will be used to complete as many of the herbaria reviews as searches as possible.

7. Budget

7.1 Cost of field inventories and other field studies

The projects described here will be coordinated through the National Park Service's Colorado Plateau Cooperative Ecosystem Studies Unit (CPCESU), with most or all of the funds transferred through the cooperative agreements that the CPCESU has with participating agencies and universities. For that reason, budget calculations have been standardized using vehicle and mileage rates and pay rates used by Northern Arizona University, where the CPCESU is located and administered. Per diem rates are a flat "camping" rate used by the University, except as specified (these costs may be reduced or eliminated if housing is available at cooperating park areas). Contributed costs on some projects include the CPCESU I&M coordinator (on some of the plant projects), project scientists from the USGS / Aridland Field Station and the USGS / Colorado Plateau Field Station (Bogan, Drost, Mattson, contributed from USGS / BRD), and the GIS Specialist (Arundel) from the USGS / Colorado Plateau Field Station (contributed by USGS / BRD). The 15% indirect cost rate on monies brought through the CPCESU is the indirect rate negotiated by the CESU with Northern Arizona University.

For most projects, exact mileages were estimated, from the office that will conduct the work (e.g. the USGS Aridland Field Station, Albuquerque, NM, or the Navajo Nation Heritage office in Window Rock, AZ) to the park units where the work is being conducted. For some of the later projects, cooperators will be selected by the CPCESU in the year preceding the start of the project. In these cases, mileage for travel on the projects was calculated not to exceed 600 miles round-trip. Some additional travel funding has been included in the Coordinator budget to cover travel for cooperation and integration of study methods across the network, and for coordination with the northern Colorado Plateau network.

7.1.1 Birds

Annual budgets for projects inventorying breeding and non-breeding birds are detailed in the tables on the following pages. Individual projects are defined on the basis of planning clusters, and by project priority, as explained in the preceding sections.

Avian Inventory for AZRU, YUHO:
Priority 1 Cluster 1 National Parks 2001-2003

Item	Year 1	Year 2	Year 3
Personnel Costs			
Project Leader			
1 Project Leader @ $340 per week (half time) x 5 wks	$1,700	$1,700	$900
Benefits @ 33%	$1,980	$1,584	$297
Field Technicians			
1 technician x 12 weeks @ $480 per week (full time)	$5,760	$5,760	$0
Fringe Benefits @ 9.31% (workman comp., etc.)	$536	$536	$0
Personnel Costs total	**$9,976**	**$9,580**	**$1,197**
Travel and Per diem			
Vehicle and Mileage costs			
1 vehicle @ $175 per week x 10 weeks	$1,750	$1,750	$0
Travel between parks (breeding, 3 visits) @ $0.12 per mi x 2145	$257	$257	$129
Travel between parks (non-breeding, 3 visits) @ $0.12 per mi x 1430	$172	$172	$0
Per diem			
Per diem @ $20 per day per person x 2 (40 days)	$1,600	$1,600	$40
Travel costs total	**$3,779**	**$3,779**	**$169**
Miscellaneous Costs			
Binoculars: 1 pair @ 350 per pair	$350	$0	$0
Rangefinders: 2 pair @ $350.00 per pair	$700	$0	$0
Tape Recorders: 4 @ $30.00 each	$120	$0	$0
Global Positioning Systems: 1 @ $150.00	$150	$0	$0
Camping Supplies (Tents, coolers etc.)	$300	$150	$0
Film, Batteries, clipboards, data books etc.	$200	$100	$0
Xeroxing, report reproduction, etc.	$200	$200	$300
Miscellaneous Costs Total	**$2,020**	**$450**	**$300**
Total Direct Costs	**$15,775**	**$13,809**	**$1,666**
Total Indirect Costs (CESU @ 15% of direct costs)	**$2,366**	**$2,071**	**$250**
Total Costs	**$18,142**	**$15,881**	**$1,916**

Avian Inventory for CACH and HUTR

Priority 1 Cluster 2 National Parks 2001-2003

Item	Year 1	Year 2	Year 3
Personnel Costs			
Project Leader			
1 Project Leader @ $340 per week (half time)	$1,360	$1,360	$680
Benefits @ 33%	$449	$449	$224
Field Technicians			
2 technicians x 7 weeks @ $480 per week (full time)	$6,720	$6,720	$0
Fringe Benefits @ 9.31% (workman comp., etc.)	$626	$626	$0
Personnel Costs total	**$9,154**	**$9,154**	**$904**
Travel and Per diem			
Vehicle and Mileage costs			
1 vehicle @ $175 per week x 8 weeks	$1,400	$1,400	$50
Travel between parks (breeding, 3 visits) @ $0.12 per mi x 300 mi / trip	$108	$108	$36
Travel between parks (non-breeding, 2 visits) @ $0.12 per mi x 300	$72	$72	$0
Per diem			
Per diem @ $20 per day per person (20 days)	$400	$400	$40
Travel costs total	**$1,980**	**$1,980**	**$126**
Miscellaneous Costs			
Binoculars: 1 pair @ 350 per pair	$350	$0	$0
Camping Supplies (Tents, coolers etc.)	$150	$0	$0
Film, Batteries, clipboards, data books etc.	$100	$50	$0
Xeroxing, report reproduction, etc.	$100	$100	$250
Miscellaneous Costs Total	**$700**	**$150**	**$250**
Total Direct Costs	**$11,834**	**$11,284**	**$1,280**
Total Indirect Costs (CESU @ 15% of direct costs)	**$1,775**	**$1,693**	**$192**
Total Costs	**$13,610**	**$12,977**	**$1,472**

Avian Inventory for ELMO, PETR, SAPU:

Priority 1 Cluster 3 National Parks 2001-2003

Item	Year 1	Year 2	Year 3
Personnel Costs			
Project Leader			
1 Project Leader @ $300 per week (half time)	$6,000	$4,800	$1,200
Benefits @ 33%	$1,980	$1,584	$396
Field Technicians			
1 technician x 12 weeks @ $480 per week (full time)	$5,760	$5,760	$0
Fringe Benefits @ 9.31% (workman comp., etc.)	$536	$536	$0
Personnel Costs total	**$14,276**	**$12,680**	**$1,596**
Travel and Per diem			
Vehicle and Mileage costs			
1 vehicle @ $175 per week x 10 weeks	$1,750	$1,750	$175
Travel between parks (breeding, 3 visits) @ $0.12 per mi x 878	$316	$316	$105
Travel between parks (non-breeding, 3 visits) @ $0.12 per mi x 878	$316	$316	$0
Per diem			
Per diem @ $20 per day per person (40 days)	$1,600	$1,600	$80
Travel costs total	**$3,982**	**$3,982**	**$360**
Miscellaneous Costs			
Binoculars: 2 pair @ 350 per pair	$700	$0	$0
Rangefinders: 2 pair @ $350.00 per pair	$700	$0	$0
Tape Recorders: 4 @ $30.00	$120	$0	$0
Global Positioning Systems: 1 @ $150.00	$150	$0	$0
Camping Supplies (Tents, coolers etc.)	$300	$150	$0
Film, Batteries, clipboards, data books etc.	$200	$100	$0
Xeroxing, report reproduction, etc.	$200	$200	$300
Miscellaneous Costs Total	**$2,370**	**$450**	**$300**
Total Direct Costs	**$20,628**	**$17,112**	**$2,256**
Total Indirect Costs (CESU @ 15% of direct costs)	**$3,094**	**$2,567**	**$338**
Total Costs	**$23,723**	**$19,679**	**$2,595**

Avian Inventory for ELMA

Priority 2 Cluster 6 National Parks 2002-2004

Item	Year 1	Year 2	Year 3
Personnel Costs			
Project Leader			
1 Project Leader @ $300 per week (half time)	$1,200	$1,200	$600
Benefits @ 33%	$396	$396	$198
Field Technicians			
1 technician x 12 weeks @ $480 per week (full time)	$5,760	$5,760	$0
Fringe Benefits @ 9.31% (workman comp., etc.)	$536	$536	$0
Personnel Costs total	**$7,892**	**$7,892**	**$798**
Travel and Per diem			
Vehicle and Mileage costs			
1 vehicle @ $175 per week x 8 weeks	$1,400	$1,400	$50
Travel between parks (breeding, 3 visits) @ $0.12 per mi x 520	$187	$187	$62
Travel between parks (non-breeding, 3 visits) @ $0.12 per mi x 520	$187	$187	$0
Per diem			
Per diem @ $20 per day per person (20 days)	$800	$800	$40
Travel costs total	**$2,574**	**$2,574**	**$152**
Miscellaneous Costs			
Binoculars 1 pair @350 per pair	$350	$0	$0
Camping Supplies (Tents, coolers etc.)	$150	$0	$0
Film, Batteries, clipboards, data books etc.	$100	$50	$0
Xeroxing, report reproduction, etc.	$100	$100	$250
Miscellaneous Costs Total	**$700**	**$150**	**$250**
Total Direct Costs	**$11,167**	**$10,617**	**$1,200**
Total Indirect Costs (CESU @ 15% of direct costs)	**$1,675**	**$1,592**	**$180**
Total Costs	**$12,842**	**$12,209**	**$1,380**

7.1.2 Mammals

Workshop budget. -- A total of $12,000 will be allocated to conducting this workshop: $1,000 for supplies, and rental of facilities; $11,000 to cover travel expenses. Most travel money will be used to defray the expenses of invited presenters. We anticipate attendance by five or six experts on mountain lions, and three or four experts on black bears in the western U.S. Remaining travel funds will be used to defray expenses of NPS personnel unable to pay for travel out of other budgets. Priority will be given to personnel directly involved with management of wildlife in their respective parks.

Budget item	*Fiscal 2001*
Personnel Costs	
Contributed time from NPS, USGS	$0
Travel costs (invited experts)	
Air fare, mileage	$5,500
Lodging	$4,500
Equipment and Miscellaneous Costs	
Meeting room / facilities (2 days) $21,500 for year 1)	$500
AV Equipment, other support costs	$500
Subtotal	**$12,000**
Indirect, 15%	**$1,800**
Total	**$13,800**

Following are budgets for Clusters 3-6. Work for Cluster 1 (AZRU and YUHO) is already underway under an Interagency Agreement with the USGS. Work in Cluster 1 is not funded by this proposal, and is not shown below.

Mammal Inventory for HUTR and NAVA

Priority 1 Cluster 2 National Parks 2001-2003

Item	Year 1	Year 2	Year 3
Personnel Costs			
Project Leader			
1 Project Leader @ $300 per week (half time)	$1,500	$1,500	$900
Benefits @ 33%	$495	$495	$297
Field Technicians			
2 technicians x 5 weeks @ $480 per week (full time)	$4,800	$4,800	$0
Fringe Benefits @ 9.31% (workman comp., etc.)	$447	$447	$0
Personnel Costs total	**$7,242**	**$7,242**	**$1,197**
Travel and Per diem			
Vehicle and Mileage costs			
1 vehicle @ $175 per week x 5 weeks	$875	$875	$0
Mileage @ $0.12 per mi x 3333 mi	$400	$400	$0
Per diem			
Per diem @ $20 per day per person (75 days)	$1,500	$1,500	$0
Travel costs total	**$2,775**	**$2,775**	**$0**
Miscellaneous Costs			
Office -- supplies and printing	$250	$200	$100
Computer / Software	$750	$150	$0
Traps, nets, other	$750	$400	$0
Supplies (bait, curation materials, film)	$400	$400	$0
Miscellaneous Costs Total	**$2,150**	**$1,150**	**$100**
Total Direct Costs	**$12,167**	**$11,167**	**$1,297**
Total Indirect Costs (CESU @ 15% of direct costs)	**$1,825**	**$1,675**	**$195**
Total Costs	**$13,992**	**$12,842**	**$1,492**

Mammal Inventory for ELMO, PETR, SAPU:
Priority 1 Cluster 3 National Parks 2001-2002

Item	Year 1	Year 2
Personnel Costs		
Project Leader		
1 Project Leader (contributed time from USGS / BRD)	$0	$0
Field Technicians		
2 technician x 13 weeks @ $480 per week (full time)	$12,810	$12,810
Fringe Benefits @ 9.31% (workman comp., etc.)	$1,315	$1,315
Personnel Costs total	**$14,125**	**$14,125**
Travel and Per diem		
Vehicle and Mileage costs		
1 vehicle @ $175 per week x 12 weeks	$2,100	$2,100
Mileage @ $0.12 per mi x 3333 mi	$400	$400
Motel @ 67$ per night x 17 night x 2	$1,200	$1,200
Per diem		
Per diem @ $20 per day per person (65 days x 2)	$2,600	$2,600
Travel costs total	**$6,300**	**$6,300**
Miscellaneous Costs		
Office -- supplies and printing	$2,175	$2,175
Traps, nets, other	$1,000	$1,000
Curation and data management	$1,500	$1,500
Miscellaneous Costs Total	**$4,675**	**$4,675**
Total Direct Costs	**$25,100**	**$25,100**
Total Indirect Costs (CESU @ 15% of direct costs)	**$3,765**	**$3,765**
Total Costs	**$28,865**	**$28,865**

Mammal Inventory for WACA and WUPA

Priority 1 Cluster 4 National Parks 2002-2003

Item	Year 1	Year 2
Personnel Costs		
Project Leader		
1 Project Leader (contributed time from USGS / BRD)	$0	$0
Field Technicians		
1 technician x 8 weeks @ $480 per week (full time)	$3,840	$3,840
Fringe Benefits @ 9.31% (workman comp., etc.)	$358	$358
Personnel Costs total	**$4,198**	**$4,198**
Travel and Per diem		
Vehicle and Mileage costs		
1 vehicle @ $175 per week x 8 weeks	$1,400	$1,400
Mileage @ $0.12 per mi x 4400 mi	$528	$528
Per diem		
Per diem @ $20 per day per person (20 days)	$400	$400
Travel costs total	**$2,328**	**$2,328**
Miscellaneous Costs		
Office -- supplies and printing	$250	$200
Computer / Software	$750	$150
Traps, nets, other	$750	$400
Supplies (bait, curation materials, film)	$400	$400
Miscellaneous Costs Total	**$2,150**	**$1,150**
Total Direct Costs	**$8,676**	**$7,676**
Total Indirect Costs (CESU @ 15% of direct costs)	**$1,301**	**$1,151**
Total Costs	**$9,977**	**$8,827**

Mammal Inventory for BAND, CHCU, ELMA:
Priority 2 Clusters 5 and 6 National Parks 2002-2003

Item	Year 1	Year 2
Personnel Costs		
Project Leader		
1 Project Leader (contributed time from USGS / BRD)	$0	$0
Field Technicians		
2 technician x 14.2 weeks @ $480 per week (full time)	$13,694	$13,694
Fringe Benefits @ 9.31% (workman comp., etc.)	$1,406	$1,406
Personnel Costs total	**$15,100**	**$15,100**
Travel and Per diem		
Vehicle and Mileage costs		
1 vehicle @ $175 per week x 12 weeks	$2,100	$2,100
Mileage @ $0.12 per mi x 3333 mi	$400	$400
Motel @ 67$ per night x 12 night x 2	$1,600	$1,600
Per diem		
Per diem @ $20 per day per person (70 days x 2)	$2,800	$2,800
Travel costs total	**$6,900**	**$6,900**
Miscellaneous Costs		
Office -- supplies and printing	$4,000	$4,000
Traps, nets, other	$1,500	$1,500
Curation and data management	$2,000	$2,000
Miscellaneous Costs Total	**$7,500**	**$7,500**
Total Direct Costs	**$29,500**	**$29,500**
Total Indirect Costs (CESU @ 15% of direct costs)	**$4,425**	**$4,425**
Total Costs	**$33,925**	**$33,925**

7.1.3 Amphibians and Reptiles

Annual budgets for projects inventorying amphibians and reptiles are detailed in the following tables. Individual projects are defined on the basis of planning clusters. Regarding details of budget calculation, the work week for each trip is based on the amount of time needed to conduct adequate surveys in each cluster, rather than a set 10 days on / 4 days off schedule, and will necessarily be flexible depending on field conditions. Equipment costs include costs associated with specimen preparation, and costs of equipment and expendables, based on similar inventory studies (e.g., Drost and Nowak 1997, Drost et al. 2000). Travel costs include mileage incurred during road driving. Contributed costs assume donation of Park Service housing to visiting researcher, if space is available, and donation of the use of computer, camera, and GPS technology by the researchers and/or the Park Service.

Herpetological Inventory for AZRU, YUHO:
Priority 1 Cluster 1 National Parks 2001-2003

Item	Year 1	Year 2	Year 3
Personnel Costs			
Project Leader			
1 Project Leader @ $17/hr x 20 hr/wk (half time)	$4,080	$4,080	$4,080
Benefits @ 33%	$1,346	$1,346	$1,346
Field Technicians			
1 technician @ $96/day x 6 days/trip x 3 trips/yr	$1,728	$1,728	$0
Fringe Benefits @ 9.31% (workman comp., etc.)	$161	$161	$0
Personnel Costs total	**$7,315**	**$7,315**	**$5,426**
Travel and Per diem			
Vehicle and Mileage costs			
1 vehicle @ $175 per week x 3 weeks	$525	$525	$0
Travel to, between, and from parks @ 0.12/mile x 600 miles/trip x 3 trips	$216	$216	$0
Per diem			
Per diem @ $20 per day per person x 2 (15 days)	$600	$600	$0
Travel costs total	**$1,341**	**$1,341**	**$0**
Miscellaneous Costs			
Measuring equipment (scales, tapes, field guides, snake sticks, etc.)	$500	$0	$0
Specimen preparation and storage (alcohol, jars, lids, labels)	$100	$50	$50
Film, developing, batteries, clipboards, data books etc.	$100	$100	$0
Xeroxing, report reproduction, etc.	$25	$25	$50
Miscellaneous Costs Total	**$725**	**$175**	**$100**
Total Direct Costs	**$9,381**	**$8,831**	**$5,526**
Total Indirect Costs (CESU @ 15% of direct costs)	**$1,407**	**$1,325**	**$829**
Total Costs	**$10,788**	**$10,156**	**$6,355**

Herpetological Inventory for CACH, HUTR, NAVA:
Priority 1 Cluster 2 National Parks 2001-2003

Item	Year 1	Year 2	Year 3
Personnel Costs			
Project Leader			
1 Project Leader @ $17/hr x 20 hr/wk x 12 wk/yr	$4,080	$4,080	$2,040
Benefits @ 33%	$1,346	$1,346	$1,346
Field Technicians			
2 technicians @ $12/hr x 8 hr/day x 9 days/trip x 3 trips	$5,184	$5,184	$0
Fringe Benefits @ 9.31% (workman comp., etc.)	$483	$483	$0
Personnel Costs total	**$11,093**	**$11,093**	**$3,386**
Travel and Per diem			
Vehicle and Mileage costs			
1 vehicle @ $175 per week x 6 wk/yr	$1,050	$1,050	$0
Travel to, between, and from parks @ 0.12/mile x 600 miles/trip x 3 trips	$216	$216	$0
Per diem			
Per diem @ $20 per day per person x 3 (30 days)	$1,800	$1,800	$0
Travel costs total	**$3,066**	**$3,066**	**$0**
Miscellaneous Costs			
Measuring equipment (scales, tapes, field guides, snake sticks, etc.)	$500	$0	$0
Specimen preparation and storage (alcohol, jars, lids, labels)	$100	$50	$50
Film, developing, batteries, clipboards, data books etc.	$100	$100	$0
Xeroxing, report reproduction, etc.	$25	$25	$50
Miscellaneous Costs Total	**$725**	**$175**	**$100**
Total Direct Costs	**$14,884**	**$14,334**	**$3,486**
Total Indirect Costs (CESU @ 15% of direct costs)	**$2,233**	**$2,150**	**$523**
Total Costs	**$17,116**	**$16,484**	**$4,009**

Herpetological Inventory for ELMO, PETR, SAPU:
Priority 1 Cluster 3 National Parks 2001-2003

Item	Year 1	Year 2	Year 3
Personnel Costs			
Project Leader			
1 Project Leader @ $17/hr x 20 hr/wk x 12 wk/yr	$4,080	$4,080	$2,040
Benefits @ 33%	$1,346	$1,346	$1,346
Field Technicians			
1 technician @ $12/hr x 8 hr/day x 11 days/trip x 3 trips	$3,168	$3,168	$0
Fringe Benefits @ 9.31% (workman comp., etc.)	$295	$295	$0
Personnel Costs total	**$8,889**	**$8,889**	**$3,386**
Travel and Per diem			
Vehicle and Mileage costs			
1 vehicle @ $175 per week x 6 wk/yr	$1,050	$1,050	$0
Travel to, between, and from parks @ 0.12/mile x 600 miles/trip x 3 trips	$216	$216	$0
Per diem			
Per diem @ $20 per day per person x 2 (30 days)	$1,200	$1,200	$0
Travel costs total	**$2,466**	**$2,466**	**$0**
Miscellaneous Costs			
Measuring equipment (scales, tapes, field guides, snake sticks, etc.)	$500	$0	$0
Specimen preparation and storage (alcohol, jars, lids, labels)	$100	$50	$50
Film, developing, batteries, clipboards, data books etc.	$100	$100	$0
Xeroxing, report reproduction, etc.	$25	$25	$50
Miscellaneous Costs Total	**$725**	**$175**	**$100**
Total Direct Costs	**$12,080**	**$11,530**	**$3,486**
Total Indirect Costs (CESU @ 15% of direct costs)	**$1,812**	**$1,729**	**$523**
Total Costs	**$13,892**	**$13,259**	**$4,009**

Herpetological Inventory for WUPA, SUCR, WACA:
Priority 1 Cluster 4 National Parks 2001-2003

Item	Year 1	Year 2	Year 3
Personnel Costs			
Project Leader			
1 Project Leader @ $17/hr x 20 hr/wk x 12 wk/yr	$4,080	$4,080	$4,080
Benefits @ 33%	$1,346	$1,346	$1,346
Field Technicians			
1 technician @ $12/hr x 8 hr/day x 11 days/trip x 3 trips	$3,168	$3,168	$0
Fringe Benefits @ 9.31% (workman comp., etc.)	$295	$295	$0
Personnel Costs total	**$8,889**	**$8,889**	**$5,426**
Travel and Per diem			
Vehicle and Mileage costs			
1 vehicle @ $175 per week x 6 wk/yr	$1,050	$1,050	$0
Travel to, between, and from parks @ 0.12/mile x 600 miles/trip x 3 trips	$216	$216	$0
Per diem			
Per diem @ $20 per day per person x 2 (30 days)	$1,200	$1,200	$0
Travel costs total	**$2,466**	**$2,466**	**$0**
Miscellaneous Costs			
Measuring equipment (scales, tapes, field guides, snake sticks, etc.)	$500	$0	$0
Specimen preparation and storage (alcohol, jars, lids, labels)	$100	$50	$50
Film, developing, batteries, clipboards, data books etc.	$100	$100	$0
Xeroxing, report reproduction, etc.	$25	$25	$50
Miscellaneous Costs Total	**$725**	**$175**	**$100**
Total Direct Costs	**$12,080**	**$11,530**	**$5,526**
Total Indirect Costs (CESU @ 15% of direct costs)	**$1,812**	**$1,730**	**$829**
Total Costs	**$13,892**	**$13,260**	**$6,355**

Herpetological Inventory for BAND, CHCU:
Priority 2 Cluster 5 National Parks 2002-2004

Item	Year 1	Year 2	Year 3
Personnel Costs			
Project Leader			
1 Project Leader @ $17/hr x 20 hr/wk x 14 wk/yr	$4,760	$4,760	$4,760
Benefits @ 33%	$1,571	$1,571	$1,571
Field Technicians			
3 technicians @ $12/hr x 8 hr/day x 11 days/trip x 4 trips	$12,672	$12,672	$0
Fringe Benefits @ 9.31% (workman comp., etc.)	$1,180	$1,180	$0
Personnel Costs total	**$20,183**	**$20,183**	**$6,331**
Travel and Per diem			
Vehicle and Mileage costs			
1 vehicle @ $175 per week x 8 wk/yr	$1,400	$1,400	$0
Travel to, between, and from parks @ 0.12/mile x 600 miles/trip x 4 trips	$288	$288	$0
Per diem			
Per diem @ $20 per day per person x 4 (36 days)	$2,880	$2,880	$0
Travel costs total	**$4,568**	**$4,568**	**$0**
Miscellaneous Costs			
Measuring equipment (scales, tapes, field guides, snake sticks, etc.)	$500	$0	$0
Specimen preparation and storage (alcohol, jars, lids, labels)	$100	$50	$50
Film, developing, batteries, clipboards, data books etc.	$100	$100	$0
Xeroxing, report reproduction, etc.	$25	$25	$50
Miscellaneous Costs Total	**$725**	**$175**	**$100**
Total Direct Costs	**$25,476**	**$24,926**	**$6,431**
Total Indirect Costs (CESU @ 15% of direct costs)	**$3,821**	**$3,739**	**$965**
Total Costs	**$29,297**	**$28,664**	**$7,395**

Herpetological Inventory for ELMA, GLCA, RABR:
Priority 2 Clusters 6-7 National Parks 2002-2004

Item	Year 1	Year 2	Year 3
Personnel Costs			
Project Leader			
1 Project Leader @ $17/hr x 20 hr/wk x 14 wk/yr	$4,760	$4,760	$4,760
Benefits @ 33%	$1,571	$1,571	$1,571
Field Technicians			
3 technicians @ $12/hr x 8 hr/day x 11 days/trip x 4 trips	$12,672	$12,672	$0
Fringe Benefits @ 9.31% (workman comp., etc.)	$1,180	$1,180	$0
Personnel Costs total	**$20,183**	**$20,183**	**$6,331**
Travel and Per diem			
Vehicle and Mileage costs			
1 vehicle @ $175 per week x 8 wk/yr	$1,400	$1,400	$0
Travel to, between, and from parks @ 0.12/mile x 600 miles/trip x 4 trips	$288	$288	$0
Per diem			
Per diem @ $20 per day per person x 4 (36 days)	$2,880	$2,880	$0
Travel costs total	**$4,568**	**$4,568**	**$0**
Miscellaneous Costs			
Measuring equipment (scales, tapes, field guides, snake sticks, etc.)	$500	$0	$0
Specimen preparation and storage (alcohol, jars, lids, labels)	$100	$50	$50
Camping equipment (coolers, tents, etc.)	$400	$100	
Film, developing, batteries, clipboards, data books etc.	$100	$100	$0
Xeroxing, report reproduction, etc.	$25	$25	$50
Miscellaneous Costs Total	**$1,125**	**$275**	**$100**
Total Direct Costs	**$25,876**	**$25,026**	**$6,431**
Total Indirect Costs (CESU @ 15% of direct costs)	**$3,881**	**$3,754**	**$965**
Total Costs	**$29,757**	**$28,779**	**$7,395**

7.1.4 Vascular plants

Vascular Plant Inventory for AZRU, YUHO
Priority 1 Cluster 1 National Parks 2001-2002

Item	Year 1	Year 2
Personnel Costs		
Project Leader		
1 Project Leader (contributed from CESU, I&M Coordinator)	$0	$0
Field Technicians		
1 technician @ $96 per day x 12 days	$1,152	$1,152
Fringe Benefits @ 9.31% (workman comp., etc.)	$107	$107
Personnel Costs total	**$1,259**	**$1,259**
Travel and Per diem		
Vehicle and Mileage costs		
1 vehicle @ $175/wk x 2 weeks	$350	$350
Travel between parks @ $0.12 per mi x 1540 miles	$185	$185
Per diem		
Per diem @ $20 per day x 26 days	$520	$520
Housing @ $20 per day x 18 days	$360	$360
Travel costs total	**$1,415**	**$1,415**
Miscellaneous Costs		
Measuring equipment, plant presses	$400	$400
Global Positioning System: 1 @ $150	$150	$0
Film, Batteries, clipboards, data books etc.	$50	$50
Miscellaneous Costs Total	**$600**	**$450**
Total Direct Costs	**$3,274**	**$3,124**
Total Indirect Costs (CESU @ 15% of direct costs)	**$491**	**$469**
Total Costs	**$3,765**	**$3,593**

Vascular Plant Inventory for ELMO, PETR

Priority 1 Cluster 3 National Parks 2001-2002

Item	Year 1	Year 2
Personnel Costs		
Project Leader		
1 Project Leader (contributed from CESU, I&M Coordinator)	$0	$0
Field Technicians		
1 technician @ $96 per day x 20 days	$1,920	$1,920
Fringe Benefits @ 9.31% (workman comp., etc.)	$179	$179
Personnel Costs total	**$2,099**	**$2,099**
Travel and Per diem		
Vehicle and Mileage costs		
1 vehicle @ $175/wk x 3 weeks	$525	$525
Travel between parks @ $0.12 per mi x 2660 miles	$319	$319
Per diem		
Per diem @ $20 per day x 40	$800	$800
Housing @ $20 per day x 36 days	$720	$720
Travel costs total	**$2,364**	**$2,364**
Miscellaneous Costs		
Measuring equipment, plant presses	$400	$400
Film, Batteries, clipboards, data books etc.	$50	$50
Miscellaneous Costs Total	**$450**	**$450**
Total Direct Costs	**$4,913**	**$4,913**
Total Indirect Costs (CESU @ 15% of direct costs)	**$737**	**$737**
Total Costs	**$5,650**	**$5,650**

Vascular Plant Inventory for CACH, HUTR, NAVA:
Priority 1 Cluster 2 National Parks 2001-2003

Item	Year 1	Year 2	Year 3
Personnel Costs			
Project Leader			
Botanist @ $17.00/hr x 40 hr/wk x 16 wks/yr 1, 9 wks/yr 2, 6 wks/yr 3	$10,880	$6,120	$4,080
Benefits @ 33%	$3,590	$2,020	$1,346
Field Technicians			
1 technician @ $15/hr x 40 hrs/wk x 9 wks/yr 1, 6 wks/yr 2, 4 wks/yr 3	$5,400	$3,600	$2,400
Fringe Benefits @ 9.31% (workman comp., etc.)	$503	$335	$223
Personnel Costs total	**$20,373**	**$12,075**	**$8,050**
Travel and Per diem			
Vehicle and Mileage costs			
Travel @ $0.33/mi x 400 miles x 11 trips/yr 1, 6 trips/yr 2, 4 trips/yr 3	$1,452	$792	$528
Per diem			
Per diem @ $20/day/person x 2 x 45 days/yr 1, 30 days/yr 2, 20 days/yr 3	$1,800	$1,200	$800
Travel costs total	**$3,252**	**$1,992**	**$1,328**
Miscellaneous Costs			
Measuring equipment, plant presses	$200	$150	$150
1 Global Positioning System	$150	$0	$0
1 Camera	$250	$0	$0
Camping supplies	$375	$125	$125
Specimen preparation (glue, mounting paper & labels)	$275	$225	$225
Xeroxing, report reproduction, etc.	$250	$250	$250
Film, Batteries, clipboards, data books etc.	$250	$250	$250
Miscellaneous Costs Total	**$1,750**	**$1,000**	**$1,000**
Total Direct Costs	**$25,375**	**$15,067**	**$10,378**
Total Indirect Costs (CESU @ 15% of direct costs)	**$3,806**	**$2,260**	**$1,557**
Total Costs	**$29,181**	**$17,327**	**$11,935**

Vascular Plant Inventory for GLCA:
Priority 2 Cluster 7 National Parks 2002-2004

Item	Year 1	Year 2
Personnel Costs		
Project Leader		
Botanist	$11,892	$12,808
Benefits @ 9.31%	$1,107	$1,192
Field Technicians		
Personnel Costs total	**$12,999**	**$14,000**
Travel and Per diem		
Vehicle and Mileage costs		
Heliocopter support- 8 hours @ $800 per hour	$6,400	$6,400
Travel and Per diem (field work, workshops, herbarium visits)	$1,500	$1,500
Travel costs total	**$7,900**	**$7,900**
Miscellaneous Costs		
Measuring equipment, plant presses	$200	$200
1 Global Positioning System	$150	$0
Camping supplies	$350	$300
Xeroxing, report reproduction, etc.	$100	$300
Film	$100	$100
Miscellaneous Costs Total	**$900**	**$900**
Total Direct Costs	**$21,799**	**$22,800**
Total Indirect Costs (CESU @ 15% of direct costs)	**$3,270**	**$3,420**
Total Costs	**$25,069**	**$26,220**

Special Status Species Inventories for BAND, CHCU

Priority 2 Cluster 5 National Parks 2003-2004

Item	Year 1	Year 2
Personnel Costs		
Salary Support	$12,000	$0
Personnel Costs total	**$12,000**	**$0**
Travel and Per diem		
Workshops, herbarium visits	$500	$500
Per diem	$800	$600
Travel costs total	**$1,300**	**$1,100**
Miscellaneous Costs		
Herbarium supplies	$400	$200
Field equipment, camping supplies	$600	$300
Global Positioning System: 2 @ $150 each	$300	$0
Office and computer supplies	$200	$300
Film, Batteries, clipboards, data books etc.	$200	$100
Miscellaneous Costs Total	**$1,700**	**$900**
Total Direct Costs	**$15,000**	**$2,000**
Total Indirect Costs (CESU @ 15% of direct costs)	**$2,250**	**$300**
Total Costs	**$17,250**	**$2,300**

Special Status Species Inventories for GRCA

Priority 2 Cluster 8 National Parks 2003-2004

Item	Year 1	Year 2
Personnel Costs		
Salary Support	$8,000	$0
Personnel Costs total	**$8,000**	**$0**
Travel and Per diem		
Workshops, herbarium visits	$500	$0
Per diem	$600	$0
Travel costs total	**$1,100**	**$0**
Miscellaneous Costs		
Herbarium supplies	$200	$0
Field equipment, camping supplies	$350	$0
Global Positioning System: 1 @ $150 each	$150	$0
Office and computer supplies	$100	$0
Film, Batteries, clipboards, data books etc.	$100	$0
Miscellaneous Costs Total	**$900**	**$0**
Total Direct Costs	**$10,000**	**$0**
Total Indirect Costs (CESU @ 15% of direct costs)	**$1,500**	**$0**
Total Costs	**$11,500**	**$0**

Special Status Species Inventories for MEVE

Priority 2 Cluster 9 National Parks 2003-2004

Item	Year 1	Year 2
Personnel Costs		
Salary Support	$8,000	$8,000
Personnel Costs total	**$8,000**	**$8,000**
Travel and Per diem		
Workshops, herbarium visits	$500	$500
Per diem	$600	$600
Travel costs total	**$1,100**	**$1,100**
Miscellaneous Costs		
Herbarium supplies	$200	$200
Field equipment, camping supplies	$350	$300
Global Positioning System: 1 @ $150 each	$150	$0
Office and computer supplies	$100	$300
Film, Batteries, clipboards, data books etc.	$100	$100
Miscellaneous Costs Total	**$900**	**$900**
Total Direct Costs	**$10,000**	**$10,000**
Total Indirect Costs (CESU @ 15% of direct costs)	**$1,500**	**$1,500**
Total Costs	**$11,500**	**$11,500**

Special Status Species Inventories for WUPA

Priority 2 Cluster 4 National Parks 2003-2004

Item	Year 1	Year 2
Personnel Costs		
Salary Support	$8,000	$0
Personnel Costs total	**$8,000**	**$0**
Travel and Per diem		
Workshops, herbarium visits	$500	$0
Per diem	$600	$0
Travel costs total	**$1,100**	**$0**
Miscellaneous Costs		
Herbarium supplies	$200	$0
Field equipment, camping supplies	$350	$0
Global Positioning System: 1 @ $150 each	$150	$0
Office and computer supplies	$100	$0
Film, Batteries, clipboards, data books etc.	$100	$0
Miscellaneous Costs Total	**$900**	**$0**
Total Direct Costs	**$10,000**	**$0**
Total Indirect Costs (CESU @ 15% of direct costs)	**$1,500**	**$0**
Total Costs	**$11,500**	**$0**

Exotic Plant Species Study for CHCU

Priority 2 Cluster 5 National Parks 2003-2004

Item	Year 1	Year 2
Personnel Costs		
Project Leader		
1 Project Leader	$2,586	
Benefits @ 33%	$853	
Personnel Costs total	**$3,439**	
Travel and Per diem		
Vehicle and Mileage costs		
1 vehicle @ $175/wk x 1.5 weeks	$263	
Travel between parks @ $0.12 per mi x 1360 mi	$163	
Per diem		
Per diem @ $20 per day x 20 days	$400	
Housing @ $20 per day x 18 days	$360	
Travel costs total	**$1,186**	
Miscellaneous Costs		
Measuring equipment, plant presses	$200	
Global Positioning System: 1 @ $150	$150	
Film, Batteries, clipboards, data books etc.	$25	
Miscellaneous Costs Total	**$375**	
Total Direct Costs	**$5,000**	
Total Indirect Costs (CESU @ 15% of direct costs)	**$750**	
Total Costs	**$5,750**	

Exotic Plant Species Study for GRCA

Priority 2 Cluster 8 National Parks 2003-2004

Item	Year 1	Year 2
Personnel Costs		
Project Leader		
1 Project Leader (park personnel)	$0	$0
Benefits @ 33%	$0	$0
Field Technicians		
1 technician @ $100 per day x 86 days	$8,700	$0
Fringe Benefits @ 9.31% (workman comp. Etc.)	$810	$0
Personnel Costs total	**$9,510**	**$0**
Travel and Per diem		
Vehicle and Mileage costs		
1 vehicle @ $175 per week x 25 days (provided by park)	$0	$0
Travel between parks @ $0.12 per mi (provided by park)	$0	$0
Per diem		
Per diem @ $20 per day x 25 days	$500	$0
Housing @ $0 per day x 25 days	$0	$0
Travel costs total	**$500**	**$0**
Miscellaneous Costs		
Measuring equipment, plant presses	$0	$0
Global Positioning System: 1 @ $150	$0	
Film, Batteries, clipboards, data books etc.	$30	$0
Miscellaneous Costs Total	**$30**	**$0**
Total Direct Costs	**$10,040**	**$0**
Total Indirect Costs (CESU @ 15% of direct costs)	**$1,506**	**$0**
Total Costs	**$11,546**	**$0**

7.1.5 Summary of costs of field inventories and other field studies

Table 8. Estimated total costs of proposed field inventories for planning clusters on the southern Colorado Plateau, by taxonomic group and priority of the inventory (i.e., project modules). Costs for mammals do not include $12,000 for the carnivore workshop. Figures include indirect costs at 15%. See Table 3 and Fig. 1 for composition and location of planning clusters.

	First Priority				***Second Priority***			
Planning Cluster	*Birds*	*Mammals*	*Amph. & Reptiles*	*Plants*	*Birds*	*Mammals*	*Amph. & Reptiles*	*Plants*
1	$35,939		$27,299	$7,358				
2	$28,059	$28,326	$37,608	$58,443				
3	$45,997	$57,730	$31,160	$11,300				
4		$18,804	$33,507					$11,500
5						$33,925	$65,356	$25,300
6					$26,431	$33,925	$32,966	
7							$32,966	$51,289
8								$23,046
9								$23,000
Totals	**$109,995**	**$104,860**	**$129,574**	**$77,101**	**$26,431**	**$67,850**	**$131,288**	**$134,135**

Table 9. Estimated total costs of proposed field inventories in NPS units on the southern Colorado Plateau, by taxonomic group, broken down by broad budget categories. Costs for mammals do not include $12,000 for the carnivore workshop.

	Taxonomic group				
Budget item	*Birds*	*Mammals*	*Amph. &Rept.*	*Plants*	**Totals**
Personnel	$85,102	$82,527	$183,388	$131,163	**482,180**
Travel	$25,439	$36,606	$36,950	$38,416	**137,411**
Equip. & misc.	$8,090	$31,050	$6,500	$14,105	**59,745**
Subtotal	$118,631	$150,183	$226,838	$183,683	**$679,3356**
15% overhead	$17,795	$24,327	$34,026	$27,552	**$103,700**
Total	$136,426	$172,710	$260,864	$211,236	**$781,236**

Table 10. Annual costs of field inventories for all taxonomic groups, by planning cluster and fiscal year, for studies in NPS units on the southern Colorado Plateau. These figures do not include $12,000 for the carnivore workshop.

Planning cluster	*Fiscal year*			
	2001	*2002*	*2003*	*2004*
1	$28,430	$25,764	$7,192	0
2	$64,260	$51,852	$16,441	0
3	$62,721	$58,655	$5,742	0
4	0	$20,756	$29,206	$5,526
5	0	$40,226	$59,676	$8,431
6	0	$25,917	$25,367	$1,200
7	0	$47,675	$47,826	$6,431
8	0	0	$20,040	0
9	0	0	$10,000	$10,000
Subtotal	**$155,411**	**$270,845**	**$221,490**	**$31,588**
Indirect, 15%	$23,312	$40,626	$33,224	$4,738
Total	**$178,723**	**$311,471**	**$254,714**	**$36,326**

7.2 Budget for Coordinators and Data Entry

Table 11. Budget for coordination and data management, for biological inventories in NPS units on the Southern Colorado Plateau. These funds go directly to the National Park Service / CPCESU, and do not incur indirect costs.

	Fiscal year		
Budget item	*2001*	*2002*	*2003*
Inventory and Monitoring Coordinator			
Personnel costs	$61,200	$63,035	$64,926
Technician (part time)	$3,200	$3,325	$3,455
Travel costs	$6,000	$6,250	$4,215
Equipment & miscellaneous costs	$2,500	$1,500	$1,500
Cost of committee meetings	$2,500	$2,500	$2,500
Data Coordinator and Data Entry			
Personnel costs (contributed time = $21,500 for year 1)	$50,548	$52,526	$53,285
Equipment and miscellaneous costs (contributed space & facilities = $3,000 for year 1)	$3,000	$1,000	$1,000
Total	**$128,948**	**$130,136**	**$130,881**

7.3 Total budget

Table 12. Total budget, by fiscal year, for biological inventory of NPS units on the Southern Colorado Plateau.

	Fiscal year				
Budget item	*2001*	*2002*	*2003*	*2004*	**Totals**
Field inventories					
Birds	$55,474	$61,379	$18,192	$1,380	**$136,425**
Mammals	$42,857	$85,609	$44,244	0	**$172,710**
Amph. & Rept.	$41,796	$112,845	$85,076	$21,146	**$260,863**
Plants	$38,596	$51,638	$107,201	$13,800	**$211,235**
Large carnivore workshop	$13,800	0	0	0	**$13,800**
Coordination & data entry	$128,948	$130,136	$130,881	0	**$389,965**
Totals	**$321,147**	**$441,607**	**$385,594**	**$36,326**	**$1,184,674**

8. Schedule

8.1 Field Inventories

All taxonomic groups within a given planning cluster will be inventoried on the same annual schedule. This will help to achieve two important objectives: (1) comparability of data among taxonomic groups by controlling for annual variation in weather, and (2) facilitation of planning and logistics for principal investigators who are inventorying more than one taxonomic group within a planning cluster. Another consideration in planning the schedule of work was minimizing, to the extent possible, variability in total annual budgets. In general, first priority projects are scheduled to begin in the first project year, and second priority projects will begin in the second or third year. Most projects are planned to last two consecutive calendar years, with most projects completing analysis and report writing in the third year. Final reports and completion of data-related tasks will be due at the end of the Federal fiscal year in the third year of each project.

Table 13. Schedule for first priority field inventories in NPS units on the Southern Colorado Plateau, for all projects within a planning cluster, by year.

Planning cluster	*2001*	*2002*	*2003*	*2004*
Field inventories				
1	1st year field work	2nd year field work	Completion of projects	
2	1st year field work	2nd year field work	Completion of projects	
3	1st year field work	2nd year field work	Completion of projects	
4		1st year field work	2nd year field work	Completion of projects
5		1st year filed work	2nd year field work	Completion of projects
6		1st year field work	2nd year field work	Completion of projects
7		1st year field work	2nd year field work	Completion of projects
8			1st year field work	2nd year field work & project completion
9			1st year field work	2nd year field work & project completion
Large carnivore workshop	Late spring			

9. Products

The project coordinator will oversee the timely completion and quality of all deliverables, and insure that products are useful to park managers. Deliverables will include written annual reports for each year of fieldwork, from each investigator. These written reports will summarize progress toward inventory objectives during the previous year, including a summary of work completed, important results, any problems or difficulties encountered, and plans for the next year. Copies of data collected during the past year will also be submitted at the same time as the annual report. In addition, researchers will need to complete the summary 'Investigator's Annual Report' for each year of fieldwork. These reports are currently submitted using an online entry form provided by NPS, and are due in January of the year following field work. The project coordinators for the southern Colorado Plateau and northern Colorado Plateau will also hold annual meetings in the fall, and project investigators will give oral presentations on progress on inventory work to staff from all of the Colorado Plateau park units. These meetings will be held in conjunction with the Colorado Plateau Biennial Research Conference (in Flagstaff, Arizona) in odd years, and in other locations in proximity to participating parks in even years, to make it easier for staff at more remote parks to attend at least some of the annual meetings.

A draft final report will be due in January of the year following completion of field work, with the revised final report due in April of that year. The project coordinator will develop an outline describing the format and content requirements for the project final report. Final copies of electronic tabular data and spatial data will be due at the time of the revised final report. These will be submitted to the Project Coordinator, who will oversee park-level and peer review, and handle distribution to the parks, the Regional I&M Coordinator, and the NPS Servicewide I&M Office. As part of project requirements, each researcher will be required to review the data in the Park Service's NPSpecies data base for the taxonomic group and parks they are working in, and submit additions and changes. In addition, researchers will submit information on all vouchers for the group they are working on. This will include copies of color slides documenting vertebrate species and plants, where these were collected, as well as data on all specimens collected. If curated specimens are not kept with the parks, the disposition of the specimens will be documented.

Upon completion of this biological inventory project, each park unit on the southern Colorado Plateau will have reports and data documenting the vascular plant flora and vertebrate fauna, and an assessment of completeness of inventory, species of special concern, and implications for management. Detailed information will be provided on the distribution and abundance of selected rare and threatened species. All data will be complete, entered and checked for accuracy, in the standard formats provided by the NPS National Inventory and Monitoring Office. *NPSpecies, NRBib, and the Dataset Catalog (or the updated versions of these) will be populated with data generated from the inventory program. GIS products, including those generated from both converted datasets and new information, will be available to parks and to regional and nationsl offices of the National Park Service. Tabular and spatial datasets and GIS products resulting from the inventory program will be produced by the inventory data manager and the GIS specialist at the Colorado Plateau Field Station. The northern and southern Colorado Plateau network data managers will cooperate to reduce duplication of effort and to maintain comparability and usefulness of products throughout the Colorado Plateau.*

In addition, distribution and abundance data on alien plant species of the four-state area of the southern Plateau will be entered into a web-based Invasive Species Information System, and those posing particular threats will be identified. The southern Colorado Plateau network parks will be prepared for implementation of long-term "vital signs" monitoring.

10. Coordination and logistical support

The Southern Colorado Plateau Network contains 19 park areas located within 4 states (Fig. 1). The SCP Network consists of 2 large park areas, 4 medium-sized parks, and 13 small parks, most of which were designated to preserve Native American cultural resources. Six of these sites do not have a natural resource manager on staff. The number of park units and the dominance of small parks dictate a centralized organization. One of our goals is to form an organization that will fully prepare us for a network-based long-term vital signs monitoring program.

Management of the Biological Inventory will be out of the Colorado Plateau Cooperative Ecosystem Studies Unit (CPCESU) office. The USGS Colorado Plateau Field Station will be a significant cooperator. Both are located on the campus of Northern Arizona University. Dr. Ron Hiebert will supervise the Project Coordinator and the Data Manager. He will also serve as liaison between the inventory programs of the Northern and Southern Colorado Plateau Networks. Dr. Anne Cully is the Project Coordinator. She is a plant ecologist very familiar with the flora of the Colorado Plateau, and she will conduct and oversee most of the vegetation survey work. Her duties will include solicitation for and selection of cooperators, development of annual plans, development of scopes of work, processing of task orders and modifications, project monitoring, quality control of project work and deliverables, and the conduct of vegetation surveys. She will obtain advice, direction, and feedback from a 6-person steering committee made up of park resource managers. Each park will have a designated biological inventory coordinator, and these coordinators will select the steering committee. Peer reviewers for proposals and products will be selected by the steering committee from the CPCESU expert data base.

Annual meetings of the park representatives, coordinators, and cooperators will be held to promote communication among the team and integration of results across parks and taxonomic groups and to share results. This will be done in conjunction with the Biennial Colorado Plateau Research Conference and other appropriate gatherings on opposite years.

This organization results in approximately 40% of project funding being spent for coordination and data management. We believe this expenditure will result in consistent, high-quality products, promote the network functioning as a team, and ensure the accuracy and usefulness of inventory data. It should also facilitate the acquisition of additional funds from other sources to conduct other needed inventory work, including distribution and abundance studies for individual species. For example, it is proposed that CPCESU project funds be utilized for two new project starts each year. It is also proposed that the CPCESU funds be utilized to support internships for minority students from Haskell Indian Nations University, Diné College and from other CPCESU partner institutions. Hiebert and Cully can also provide assistance to parks in preparing proposals for SEPAS calls (regional base, small park NRPP, NRPP) and promote the use of park fee funds to conduct high priority distribution and abundance studies within their parks.

10.1 Logistical Support Provided by Parks

- Housing, when and where available, for free or going rate
- Park and area orientation
- Field assistance when possible
- Transport to study sites when special transport required (e.g., boat, air, 4-wheel)
- Delivery and food to backcountry sites
- Office or dry lab space when available
- Time and transport of steering committee and data board

10.2 Contribution of Cooperators

Northern Arizona University

- Office space for coordinator and data management specialist
- Reduced 15% overhead rate for projects
- Complete library and computer network access
- Availability of quality student assistance
- Greatly reduced license fees for use of GIS software

USGS Colorado Plateau Field Station

- Assistance with data management, especially in sharing info with public (NBII)
- Use of GIS hardware and work space
- Contribution of salaries for principal investigators
- Assistance with populating the NPSpecies and Data Catalog

Colorado Plateau Cooperative Ecosystem Studies Unit (CPCESU)

- Access to resources in 9 institutions at a consistent and reduced overhead rate
- Expert database
- Web site for sharing information and data
- Project tracking system
- Liaison with SCP Network park units, coordination and oversight of proposal development

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12. Appendices

12.1 Appendix A: Preliminary list of vegetation types in the 19 park units of the southern Colorado Plateau

[See following pages]

Community Type	Species	AZRU	BAND	CACH	CHCU	ELMA	ELMO	GLCA	GRCA	HUTR	MEVE
Forest and Woodland											
Subalpine Spruce-Fir	*Picea engelmannii-Abies bifolia*		X						X		
Limber Pine	*Pinus flexilis*		X								
Blue Spruce	*Picea pungens*		X								
Douglas Fir	*Pseudotsuga menziesii*		X					X	X		
Douglas Fir-White Fir	*Pseudotsuga menziesii-Abies concolor*		X						X		
Aspen	*Populus tremuloides*		X						X		
Ponderosa Pine	*Pinus ponderosa*		X						X		
Gambel's Oak	*Quercus gambelii*		X					X	X		
Rocky Mountain Maple-Gambel's Oak	*Acer glabrum-Quercus gambelii*								X		
Bigtooth Maple-Gambel's Oak	*Acer grandidentatum-Quercus gambelii*							X			
Live Oak	*Quercus turbinella*							X	X		
Alligator Juniper	*Juniperus deppeana*		X								
Pinyon-Utah Juniper	*Pinus edulis-Juniperus osteosperma*	X						X	X		
Pinyon-One-seed Juniper	*Pinus edulis-Juniperus monosperma*	X	X		X				X		
One-seed Juniper	*Juniperus monosperma*				X						
Savanna											
Utah Juniper-Mixed Grass	*Juniperus osteosperma-mixed grass*							X			
One-seed Juniper-Black Grama	*Juniperus monosperma-Bouteloua eriopoda*										
One-seed Juniper-Galleta	*J. monosperma-Hilaria jamesii*										
One-seed Juniper-Blue Grama	*J. monosperma-Bouteloua gracilis*		X								
Shrubland											
Black Sagebrush	*Artemisia nova*				X				X		
Big Sagebrush	*Artemisia tridentata*	X			X			X	X		
Rubber Rabbitbrush	*Chrysothamnus nauseosus*										
Sticky-leaved Rabbitbrush	*Chrysothamnus viscidiflorus*								X		
Blackbrush	*Coleogyne ramosissima*							X	X		
Four-wing Saltbush	*Atriplex canescens*	X						X	X		
Shadscale	*Atriplex confertifolia*							X	X		
Greasewood	*Sarcobatus vermiculatus*				X						
Snakeweed	*Gutierrezia sarothrae*							X			
Desert Holly	*Atriplex hymeneletra*								X		
Goldenhead	*Acamptopappus sphaerocephalus*							X			
Winterfat	*Eurotia lanata*							X	X		
Brittlebush	*Encelia farinosa*								X		
Creosote Bush	*Larrea tridentata*								X		
Sand Shrub	*Ephedra viridis/cutleri-Artemisia filifolia*							X	X		
Mat Shrubland											
Mound Saltbush	*Atriplex corrugata*							X			
Gardner Saltbush	*Atriplex gardneri*										

Community Type	Species	AZRU	BAND	CACH	CHCU	ELMA	ELMO	GLCA	GRCA	HUTR	MEVE
Grassland											
Montane Fescue Grassland	*Festuca thurberi-Danthonia parryi*		X								
Montane mixed meadow	*numerous species*								X		
Galleta Grassland	*Hilaria jamesii*	X			X			X	X		
Stipa Grassland	*Stipe hymenoides-S. comata*							X	X		
Blue Grama Grassland	*Bouteloua gracilis*	X							X		
Blue Grama-Yucca	*B. gracilis-Yucca baccata*										
Sand Dune Grassland	*Sporobolus cryptandrus-S. contractus*							X			
Dropseed Grassland	*Sporobolus flexuosus-Stipa neomexicana*										
Alkali Sacaton Grassland	*Sporobolus airoides*				X						
Black Grama Grassland	*Bouteloua eriopoda*										
Annual Brome Grassland	*Bromus tectorum/B. rubens*							X	X		
Riparian Forest and Woodland											
Russian Olive	*Elaeagnus angustifolia*							X			
Mesquite	*Prosopis glandulosa*								X		
Goodding's Willow	*Salix gooddingii*							X	X		
Fremont Cottonwood	*Populus fremontii*	X	X		X			X	X		
Fremont Cottonwood-Goodding's Willow	*Populus fremontii-Salix gooddingii*							X	X		
Narrowleaf Cottonwood	*Populus angustifolia*		X		X						
Narrowleaf Cottonwood-Boxelder	*Populus angustifolia-Acer negundo*		X								
BoxElder	*Acer negundo*										
Riparian shrubland											
Tamarisk	*Tamarix chinensis*	X						X	X		
Coyote Willow	*Salix exigua*	X						X	X		
Birchleaf Buckthorn	*Rhamnus betulifolia*							X	X		
Apache Plume	*Fallugia paradoxa*							X	X		
Poison Ivy	*Toxicodendron rydbergii*							X			
New Mexico Olive	*Forestiera neomexicana*				X						
Catclaw	*Acacia greggii*								X		
Marshland											
Reedgrass	*Phragmites australis*	X						X	X		
Waterpocket	*Juncus tenuis-Panicum oligosanthes*							X			
Juncus wetland	*Juncus spp*							X			
Cattail	*Typha domingensis*	X						X	X		
Forbland											
Hanging Garden	*various herbaceous species*							X	X		
Tropic Shale Forbland	*Viguiera soliceps-Cleomella palmeriana*							X			

Community Type	*Species*	AZRU	BAND	CACH	CHCU	ELMA	ELMO	GLCA	GRCA	HUTR	MEVE	NAVA
Barren												
Slickrock Barren	*various species-no dominants*			X	X			X	X			X
Rocky barrens	*various species-no dominants*											
Lava Barrens	*various species-no dominants*											
Cinder Barrens	*various species-no dominants*											
Other unclassified types												
Talus communities	*various species-no dominants*							X				
Dry streambeds	*various species-no dominants*							X				

Community Type	Species	NAVA	PEFO	PETR	RABR	SAPU	SUCR	WACA	WUPA	YUHO
Forest and Woodland										
Subalpine Spruce-Fir	*Picea engelmannii-Abies bifolia*									
Limber Pine	*Pinus flexilis*									
Blue Spruce	*Picea pungens*									
Douglas Fir	*Pseudotsuga menziesii*	X						X	X	
Douglas Fir-White Fir	*Pseudotsuga menziesii-Abies concolor*	X								
Aspen	*Populus tremuloides*	X					X			
Ponderosa Pine	*Pinus ponderosa*	X					X	X	X	
Gambel's Oak	*Quercus gambelii*	X			X			X	X	
Rocky Mountain Maple-Gambel's Oak	*Acer glabrum-Quercus gambelii*									
Bigtooth Maple-Gambel's Oak	*Acer grandidentatum-Quercus gambelii*									
Live Oak	*Quercus turbinella*									
Alligator Juniper	*Juniperus deppeana*									
Pinyon-Utah Juniper	*Pinus edulis-Juniperus osteosperma*	X								
Pinyon-One-seed Juniper	*Pinus edulis-Juniperus monosperma*		X					X	X	
One-seed Juniper	*Juniperus monosperma*									
Savanna										
Utah Juniper-Mixed Grass	*Juniperus osteosperma-mixed grass*									
One-seed Juniper-Black Grama	*Juniperus monosperma-Bouteloua eriopoda*								X	
One-seed Juniper-Galleta	*J. monosperma-Hilaria jamesii*								X	
One-seed Juniper-Blue Grama	*J. monosperma-Bouteloua gracilis*			X						
Shrubland										
Black Sagebrush	*Artemisia nova*									
Big Sagebrush	*Artemisia tridentata*	X	X							
Rubber Rabbitbrush	*Chrysothamnus nauseosus*								X	
Sticky-leaved Rabbitbrush	*Chrysothamnus viscidiflorus*									
Blackbrush	*Coleogyne ramosissima*				X					
Four-wing Saltbush	*Atriplex canescens*	X		X					X	
Shadscale	*Atriplex confertifolia*	X	X						X	
Greasewood	*Sarcobatus vermiculatus*									
Snakeweed	*Gutierrezia sarothrae*								X	
Desert Holly	*Atriplex hymeneletra*									
Goldenhead	*Acamptopappus sphaerocephalus*		X							
Winterfat	*Eurotia lanata*		X	X						
Brittlebush	*Encelia farinosa*									
Creosote Bush	*Larrea tridentata*									
Sand Shrub	*Ephedra viridis/cutleri-Artemisia filifolia*	X	X	X	X					
Mat Shrubland										
Mound Saltbush	*Atriplex corrugata*									
Gardner Saltbush	*Atriplex gardneri*									

Community Type	Species	NAVA	PEFO	PETR	RABR	SAPU	SUCR	WACA	WUPA	YUHO
Grassland										
Montane Fescue Grassland	*Festuca thurberi-Danthonia parryi*									
Montane mixed meadow	*numerous species*									
Galleta Grassland	*Hilaria jamesii*	X	X	X					X	
Stipa Grassland	*Stipe hymenoides-S. comata*	X							X	
Blue Grama Grassland	*Bouteloua gracilis*	X	X	X					X	
Blue Grama-Yucca	*B. gracilis-Yucca baccata*							X		
Sand Dune Grassland	*Sporobolus cryptandrus-S. contractus*			X				X		
Dropseed Grassland	*Sporobolus flexuosus-Stipa neomexicana*								X	
Alkali Sacaton Grassland	*Sporobolus airoides*									
Black Grama Grassland	*Bouteloua eriopoda*								X	
Annual Brome Grassland	*Bromus tectorum/B. rubens*	X	X					X		
Riparian Forest and Woodland										
Russian Olive	*Elaeagnus angustifolia*	X	X							
Mesquite	*Prosopis glandulosa*									
Goodding's Willow	*Salix gooddingii*		X							
Fremont Cottonwood	*Populus fremontii*	X	X							
Fremont Cottonwood-Goodding's Willow	*Populus fremontii-Salix gooddingii*		X							
Narrowleaf Cottonwood	*Populus angustifolia*	X	X							
Narrowleaf Cottonwood-Boxelder	*Populus angustifolia-Acer negundo*	X						X		
BoxElder	*Acer negundo*							X		
Riparian shrubland										
Tamarisk	*Tamarix chinensis*	X	X		X				X	
Coyote Willow	*Salix exigua*	X	X		X					
Birchleaf Buckthorn	*Rhamnus betulifolia*	X								
Apache Plume	*Fallugia paradoxa*			X					X	
Poison Ivy	*Toxicodendron rydbergii*									
New Mexico Olive	*Forestiera neomexicana*									
Catclaw	*Acacia greggii*									
Marshland										
Reedgrass	*Phragmites australis*	X							X	
Waterpocket	*Juncus tenuis-Panicum oligosanthes*									
Juncus wetland	*Juncus spp*									
Cattail	*Typha domingensis*	X	X							
Forbland										
Hanging Garden	*various herbaceous species*	X								
Tropic Shale Forbland	*Viguiera soliceps-Cleomella palmeriana*									

Community Type	***Species***	**NAVA**	**PEFO**	**PETR**	**RABR**	**SAPU**	**SUCR**	**WACA**	**WUPA**	**YUHO**
Barren										
Slickrock Barren	*various species-no dominants*	X	X		X				X	
Rocky barrens	*various species-no dominants*			X						
Lava Barrens	*various species-no dominants*						X			
Cinder Barrens	*various species-no dominants*						X		X	
Other unclassified types										
Talus communities	*various species-no dominants*									
Dry streambeds	*various species-no dominants*									

12.2 Appendix B: Literature References and Abstracts

Literature references and abstracts pertaining to inventory at Southern Colorado Plateau park units, ordered by park unit. References are from the NPS bibliography database (NRBIB), with additions from the background work and development of this proposal (NRBIB for the SCP was completed in 1994; a library technician who was hired to assist in the development of this proposal reviewed the earlier NRBIB records, added new records since 1994, and compiled additional sources provided by regional experts). References have been reviewed, selected, and annotated by the subject matter experts contributing to this proposal, and additional references have been contributed by those experts. In general, checklists without supporting field studies and wildlife observation cards are not included, unless we were unable to find better documentation.

Aztec Ruins National Monument (AZRU)

1. Ecosphere Environmental Services, Inc. A survey for sensitive, threatened, and endangered species for the proposed Tract No. 101-24, Aztec Ruins National Monument, San Juan County, New Mexico. Farmington, NM; 1996 Jul 14+ p.

Abstract: This survey for threatened, endangered, or sensitive plant and animal species was done for a proposed addition of about 4 acres to Aztec Ruins National Monument, NM. Although none were found, the report gives brief summaries of information regarding individual plants and animals in these categories which potentially could occur in the area. No wildlife was seen, but the similar list of animals expected in or near the project area includes 6 reptiles.

Bandelier National Monument (BAND)

1. Allen, Craig D. Montane grasslands in the landscape of the Jemez Mountains, New Mexico. Madison, WI: University of Wisconsin-Madison; 1984 195 p.

Abstract: Ecological and historical description of the montane grasslands of the Jemez Mountains, NM. Appendices include checklists of grasses, forbs, amphibians, birds, mammals, reptiles and a soil profile description.

2. Allen, Craig D. and Touchan, Ramzi. Spatial analysis of prehistoric and historic fire regimes in the Jemez Mountains, New Mexico. Los Alamos, NM; 1994 19 panels).

Abstract: This is a collection of text, graphs, maps, and photographs relating to the fire history of the Jemez Mountains, NM. Information includes a map of Jemez Mountains salamander (Plethodon neomexicanus) occupation sites.

3. Author unknown. Vertebrates of Bandelier National Monument. 1990 Jul 11 p.

Abstract: This is a checklist of vertebrates found at Bandelier National Monument, NM. Scientific and common names are listed, as well as a four letter code for each species. Birds, mammals, reptiles, amphibians, and fish are listed.

4. Bogan, Michael A.; O'Shea, Thomas J.; Cryan, Paul M.; Ditto, Amy M.; Schaedla, William H.; Valdez, Ernest W.; Castle, Kevin T., and Ellison, Laura. A study of bat populations at Los Alamos National Laboratory and Bandelier National Monument, Jemez Mountains, New Mexico. Albuquerque NM: US Geological Survey, Midcontinent Ecological Science Center, Department of Biology, University of New Mexico; 1997 Dec 2; FY95-97 report to Los Alamos National Laboratory and Bandelier National Monument; LA-UR-98-2418. 135+ p.

Abstract: This study was begun to address a scarcity of information regarding the status and trends of bat populations in the Jemez Mountains of New Mexico, encompassing Bandelier National Monument. The paper describes methods, including use of the Anabat system for analyzing bat calls, and discusses results of mist-netting, radio-telemetry, and roost searches on foot. The capture and release of over 1500 bats allowed researchers to document details about 14 of the 15 bat species known from the Jemez Mountains. Of the 8 bat species considered species of concern in the area, only Corynorhinus townsendii was represented by a small enough number (7 individuals) to support consideration of the species as of concern. The report includes tables and graphs with site and capture data, elevation information, and summary statistics. Two appendices by individual authors add information about ultrasonic recording and environmental contamination in bats; the

other appendices describe sites, give species accounts of the bats known from the Jemez Mountains, and give roost and climatic data.

5. Bogan, Michael A.; O'Shea, Thomas J.; Valdez, Ernest W.; Ditto, Amy M., and Castle, Kevin T. Continued studies of bat species of concern in the Jemez Mountains, New Mexico. Albuquerque NM: US Geological Survey, Midcontinent Ecological Science Center, Department of Biology, University of New Mexico; 1998 Dec 4; FY98 report to Los Alamos National Laboratory and Bandelier National Monument. 25+ p.

Abstract: This report documents an additional year beyond a 3-year study begun to address a scarcity of information regarding the status and trends of bat populations in the Jemez Mountains of New Mexico. The study includes Bandelier National Monument. The paper describes methods, including guano collection to aid in species identification, and discusses results of mist-netting, radio-telemetry, and listening for audible calls of the spotted bat. The capture and release of over 325 bats allowed researchers to document details about all 8 of the bat species of concern in the Jemez Mountains. Of these 8 species, only Corynorhinus townsendii was captured rarely enough (1 individual, no known roost sites) to support consideration of the species as of concern. The report includes tables and graphs concerning capture data, reproductive status, and echolocation calls.

6. Degenhardt, William G., University of New Mexico, Department of Biology. Herpetofaunal Survey of Bandelier National Monument [Final Report]. National Park Service, Southwest Regional Office; 1975 Nov; PX7000-3-0530. 13 p.

Abstract: This is the result of a 2 1/2 year inventory of reptiles and amphibians at Bandelier National Monument, NM. Animal locations within the park are noted, along with the dominant vegetation type present. There are also discussions of animal distribution, abundance, and species found adjacent to the Monument but not encountered within the boundaries.

7. Fettig, Stephen M., compiler. Bird list for Bandelier National Monument. 1999 Sep 21 7 p.

Abstract: This is a common-name checklist of the birds found in Bandelier National Monument. It also contains seasonal abundance codes for the species occurring regularly in the park; other species are listed in lighter print, with a request for reports of observations to aid in determining status by season. The list was compiled based on "staff and visitor observations, published and unpublished avian research reports of avian studies at Bandelier since 1970, and comments from Carlyn Jervis, Terrell H. Johnson, Christopher M. Rustay, Roland H. Wauer, and Sartor O. Williams III."

8. Fleisher, Robert. Reptiles and amphibians of Bandelier National Monument. 1978 Summer 4 p.

Abstract: This checklist of reptiles and amphibians of Bandelier National Monument includes common names, scientific names, and some historical, temporal, and habitat information on each species.

9. Guthrie, Daniel A. and Large, Nancy, Claremont Colleges, CA. Mammals of Bandelier National Monument, New Mexico. Claremont, CA: Claremont Colleges, Joint Science Department ; 1980 Jun 1; PX7029-7-0807. 20 p.

Abstract: This paper gives distribution and frequency of mammals within Bandelier National Monument based upon sightings by park personnel and visitors prior to September 1979.

10. Jacobs, Brian F. A flora of Bandelier National Monument. Santa Fe, NM: National Park Service, Southwest Regional Office; 1989 Mar 14; PX7029-8-0484. 79 p.

Abstract: This is a checklist of vascular plants occurring at Bandelier National Monument. Nomenclature, habitat and elevational data, frequency, and distribution are all included with each entry. There is also a historical background of the herbarium at Bandelier National Monument.

11. Jacobs, Brian F. and Jacobs, E. P. A Flora of Bandelier National Monument, Part I. Los Alamos, NM: National Park Service; 1988 Jan 31; PX7120-7-0131. 55 p.

Abstract: This is a checklist of vascular plants occurring at Bandelier National Monument. Nomenclature, habitat and elevational data, frequency, and distribution are all included with each entry. There is also a historical background of the herbarium at Bandelier National Monument.

12. Platania, Steven P. Fishes of Bandelier National Monument, New Mexico. Albuquerque, NM: University of New Mexico; 1992 Apr 20 23 p.

Abstract: This is a report of fishes collected at Bandelier National Monument and adjacent drainages of the Rio Grande, NM. Collections were made on August 23, 1990, and August 13, 1991. Includes lists of species, total number of specimens, frequency of occurrence, and a map of collecting sites.

13. Wauer, Roland H. and Fletcher, Milford R. Survey of amphibians and reptiles in Bandelier National Monument. Transactions of the Southwest Region National Science Conference; Santa Fe, NM. National Park Service; 1974?: p. 86-87.

Abstract: Lists of amphibians/reptiles found within the park, those found immediately outside the park boundary (and probably present within), and those in the Jemez Mountains or Rio Grande Valley (and therefore probably in the park as well).

14. Guthrie, Daniel A. Ecological Assessment of the Lower Canyons, Bandelier National Monument. Claremont, California: Claremont Colleges; 1976 Jan 17 p.

Abstract: This is an account of animals and birds found at the mouth of Frijoles Canyon and Alamo Canyon during the summer of 1975, prior to filling the Cochiti Reservoir. The amphibians section gives common and scientific names, frequency of sightings, and a checklist. The fourth and final section is an assessment of the effects of filling Cochiti Reservoir on wildlife in Bandelier National Monument.

15. Guthrie, Daniel A., Claremont Colleges. Small Mammal Studies and Evaluation of the Status of the Jemez Mountains Salamander in Bandelier National Monument. National Park Service; 1978 Dec; PX7029-7-0807. 12 p. (Superintendents Annual Research Report).

Abstract: This is a status report of research by D. A. Guthrie during the summer of 1978. The status of the Jemez Mountain salamander (Plethodon neomexicanus) is described along with a map of sightings.

16. Guthrie, Daniel A. Status of the Jemez Mountains Salamander (Plethodon neomexicanus) Within Bandelier National Monument. Claremont, California: Claremont Colleges, Joint Science Department ; 1979 Oct; PX7029-7-0807. 7 p.

Abstract: This report relays the status and range of, and possible threats to, the Jemez Mountain salamander (Plethodon neomexicanus) within Bandelier National Monument, NM. Includes a list of observations from 1966 to 1979 and an accompanying map of locations.

17. Pierce, Lee. Untitled: Proposed research on habitat disturbance effects on the western chorus frog and the canyon treefrog. 1991. 14 p.

Abstract: This is a proposal to perform research on the effects of habitat disturbance on the western chorus frog (Pseudacris triseriata) and the canyon treefrog (Hyla arenicolor) in Los Alamos County, NM. The report is to be the author's master's thesis from the University of New Mexico. << Note: Not sure if this ever happened.>>

18. Wauer, Roland H. A Program of Research at Bandelier National Monument, a Postscript to the La Mesa Fire. Santa Fe, NM: National Park Service, Southwest Region, Natural Resources Division; 1978 11 p.

Abstract: Report documenting the research and rehabilitation in Bandelier National Monument, New Mexico, following the La Mesa fire in Santa Fe National Forest in June 1977, in which 15,000 acres were burned. Research projects included effects on Jemez Mountain salamanders (endangered).

Canyon de Chelly National Monument (CACH)

1. Burgess, Tony L., University of Arizona, Department of Biology. List of Reptiles, Amphibians, and Fish Collected in the Canyon de Chelly Region, Apache Co., Arizona. 1970 6 p.

Abstract: Survey of reptiles, amphibians, and fish in Canyon de Chelly region for Southwest Archeological Center as part of Antelope House project, 15 June - 28 August, 1970. Identifies species by scientific name, gives common name and location of capture. Summary also identifies species sighted/known but not collected.

2. ---. Mammals of the Canyon De Chelly Region, Apache Co., Arizona. 1970 15 p.

Abstract: Description of project to assess mammal population by trapping. The introductory portion describes the trapping areas, including names of plant species. Page 6-11 is a listing of the species trapped (scientific name, number caught, and locations)

3. Halse, Richard Ray. Plants of Canyon de Chelly National Monument. 1973 16 p.

Abstract: Plants of Canyon de Chelly National Monument listed alphabetically by family, tribe, genus, species.

4. Harlan, Annita and Dennis, Arthur E. A preliminary plant geography of Canyon de Chelly National Monument. Journal of the Arizona Academy of Science. 1976 Jun; 11(171):69-78.

Abstract: "The present investigation was undertaken to better characterize the major vegetation and habitat types occurring within the monument boundaries. This was done in order to relate present vegetation to past vegetation, thereby providing bases for understanding land and plant use by the ancient inhabitants of Antelope House in Canyon del Muerto." Identifies 7 habitats, includes scientific name checklist of 115 flora.

5. Hasty, Gary M. and Fletcher, David P. The wildlife of Canyon De Chelly National Monument. Tucson, AZ: Southwest Parks and Monuments Associaton//NPS; 1981.

Abstract: Common/scientific name checklist of birds, fish, mammals, and herpetofauna of Canyon De Chelly National Monument. Bird checklist includes coded annotations regarding abundance and occurrence, but no scientific names.

Chaco Culture National Historic Park (CHCU)

1. Chaco Canyon National Monument. Summary: federal and New Mexico state threatened, endangered, & "sensitive" species. 1999 Dec 3 p.

Abstract: This paper lists special-status species of San Juan and McKinley counties, New Mexico, which could occur at Chaco Culture National Historic Park. Some listed plants are known from adjacent areas, but habitat for most of these species is lacking within the park. Habitat for four of the 17 "sensitive" plant species does occur [the report does not say if any of these plants have been located within the park]. Of vertebrates, only 2 fish species and six bird species are listed as "threatened" or "endangered" for the 2 counties; several of these bird species do or may occur in the park. An additional 23 animal species in these counties are considered "sensitive" by a state or federal agency; 11 are unlikely in the park, but others may occur or have been documented in the park.

2. Cully, Anne C. Appendix A: Checklist of Plants, Chaco Canyon National Monument. Mathien, Frances Joan, editor. Environment and Subsistence of Chaco Canyon New Mexico. Albuquerque, NM: National Park Service; 1985; pp. p. 447-457. 488 p. (Publications in Archeology 18E Chaco Canyon Studies.

Abstract: Plant list. Gives family, scientific name, common name and collection. Includes a list at the end of collection locations, collectors, and dates.

3. Cully, J.F., Jr. 1985a. Appendix B: An Annotated List of the Birds of Chaco Canyon National Monument. Mathien, Frances Joan. Environment and Subsistence of Chaco Canyon New Mexico. Albuquerque, NM, National Park Service. Publications in Archeology 18E Chaco Canyon Studies. 459-475p.

4. Cully, J.F. Jr. 1985b. Chapter Six: Baseline Biology of Birds and Mammals at Chaco Canyon National Monument New Mexico. In: Mathien, F. J. (ed.) Environment and Subsistence of Chaco Canyon New Mexico. Albuquerque, NM, National Park Service. Publications in Archeology 18E Chaco Canyon Studies: 279-304

5. Jones, Kirkland L. An Ecological Survey of the Reptiles and Amphibians of Chaco Canyon National Monument, San Juan County New Mexico. Albuquerque, NM: University of New Mexico; 1970 68 p.

Abstract: The last half of the report is an annotated list of reptiles and amphibians.

6. Jones, Kirkland L. The Ecology of Chaco Canyon Preliminary Survey. Albuquerque, NM: University of New Mexico; 1972 Aug; Contract No. 14-10-7:931-47. 80 p.

Abstract: Plant Associations, results of vegetation sampling along transects (repeated at different dates), species of mammals caught in traps, black and white photographs showing vegetation (these photographs are only in the copy shelved under 571.312-2 Jo)..

7. . Mathien, Frances Joan, editor. Environment and Subsistence of Chaco Canyon New Mexico. Albuquerque, NM: National Park Service; 1985; 488 p. (Publications in Archeology 18E Chaco Canyon Studies.

Abstract: Fourteen records in this database describe individual chapters in this book, as well as the plant list in Appendix A and bird list in Appendix B. Individual authors are given for each section.

8. Valdez, Ernest W.; Haymond, Shauna; Bogan, Michael A.; Campbell, Polly, and Koontz, Terri. Bat population study and monitoring program at Chaco Culture National Historic Park, New Mexico, 1999. Albuquerque NM: US Geological Survey, Midcontinent Ecological Science Center, Department of Biology, University of New Mexico; 2000 Mar 9; FY99 report to Chaco Culture National Historic Park. 25+ p.

Abstract: Of the 15 bat species known for San Juan County, New Mexico (including 8 regarded as species of concern by the U.S. Fish and Wildlife Service), only two had been documented at Chaco Culture National Historic Park before this study. The paper describes methods, including use of the Anabat system for analyzing bat calls, and discusses results for individual species. Additional studies have been planned for FY2000. The report includes tables listing bat species known for the county, mist-netting results, the 11 species whose presence in the park was documented either by capture or by call analysis, and statistical analysis. The appendix describes the 10 sites sampled in 1999 and gives UTM coordinates.

El Malpais National Monument (ELMA)

1. Appendix 20. Amphibian and Reptile Species List for El Malapis National Monument, Lightfoot, David C.; Bleakly, David L.; Parmenter, Robert R., and Gosz, James R. Vegetation and Wildlife Inventory of El Malpais National Monument, Final Report. Albuquerque, NM: Department of Biology, University of New Mexico; 1994 Apr; CA 7029-1-0007. p. 414-416.

Abstract: Amphibians and reptiles found in El Malpais National Monument, El Morro National Monument, Cibola County, and the Zuni Mountains of New Mexico.

2. Valdez, Ernest W.; Bogan, Michael A.; Haymond, Shauna; Campbell, Polly, and Koontz, Terri. Bat survey of El Malpais National Monument and adjacent areas, New Mexico, 1999. Albuquerque NM: US Geological Survey, Midcontinent Ecological Science Center, Department of Biology, University of New Mexico; 2000 Jan 27; FY99 report to El Malpais National Monument, National Park Service. 20+ p.

Abstract: This authors of this El Malpais bat study "were particularly interested in the distribution of species across habitats, relative abundance of species, information on reproduction and activity, and in documenting the occurrence of several poorly known species in this part of New Mexico." The paper describes methods: use of the ANABAT system for analyzing bat calls, and collection of guano and ectoparasites for analysis. It also discusses results of ANABAT detection and mist-netting (over 230 captures). The one new record for the monument was for Myotis auriculus. Tables provide a list of 17 known bat species from Cibola County, capture data, and list of calls recorded; the appendix describes sampling sites.

El Morro National Monument (ELMO)

1. Anonymous. Birds of El Morro National Monument, Valencia County, New Mexico. 1979 Sep 30 90 p.

Abstract: Sections on ornithological investigation at El Morro, breeding bird censuses conducted at El Morro, and an annotated checklist of the birds of El Morro (this is the bulk of the report).

2. Anonymous. Vascular Flora of El Morro National Monument, New Mexico. 1981 May 20 67 p.

Abstract: Results of a 3-year study of the vascular plants of El Morro (undertaken between 1978 and 1980). Plants are arranged by family. Gives scientific name, common name, physical description, notes. Includes an index to scientific and common names. Makes reference to a herbarium created as a part of this work.

3. Anonymous. Birds of El Morro National Monument. 1986 Oct 6 p.

Abstract: Checklist of 151 species of birds, of which 115 have been observed in the monument's boundaries, 36 have been found within close vicinity.

4. Anonymous. Mammals of El Morro National Monument. 1986 Oct 8 p.

Abstract: Checklist of 73 species of mammals, 38 have actually been recorded within the monument, 35 have been found in the vicinity of El Morro.

5. Anonymous. Plant Checklist of El Morro National Monument. 1986 Sep 12 p.

Abstract: This is a checklist of the 264 plant species identified at El Morro. The checklist is based upon a study of the vascular flora performed by D. Archibald McCallum. Species in the checklist are listed by Latin names and common names.

6. Anonymous. Updates for El Morro Bird Checklist's Next Printing Compiled as of 12/87. 1987 1 p.

Abstract: List of changes to make to bird list - species to be added and names to be changed.

7. McCallum, D. Archibald. Amphibians, Reptiles and Mammals of El Morro National Monument, Valencia County, New Mexico. 1979 Dec 20 89 p.

Abstract: Species accounts and general descriptions of reptiles, amphibians and mammals found at El Morro National Monument.

8. Stolz, Gary M. Amphibians and Reptiles of El Morro National Monument . 1986 Oct 5 p.

Abstract: Checklist of 31 species of amphibians and reptiles, of which 20 have been recorded in the monument, 9 have been found within a few miles of the monument.

9. Sotlz, Gary M. Park Ranger. Inscription Pool Herptifauna [herpetofauna] Restoration Plan. 1986 15+ p.

Abstract: Report describing historic references to fish and amphibians in the pool with a recommendation to use Rotenone (a pesticide) to remove exotic fish species and reintroduce salamanders.

Glen Canyon National Recreation Area (GLCA)

1. Aitchison, Stewart W.; Carothers, Steven W.; Karpiscak, Martin M.; Theroux, Michael E., and Tomko, Dennis S. Amphibians and reptiles,from: Aitchison, Stewart W.; Carothers, Steven W.; Karpiscak, Martin M.; Theroux, Michael E., and Tomko, Dennis S., Contributors. An Ecological Survey of the Colorado River and its Tributaries between Lees Ferry and the Grand Wash Cliffs. Northern Arizona Society of Science and Art, Inc.; 1974 Dec; NPS Contract Nos. CX821040079 and CX821500007. 235 p.

Abstract: Photocopied list from the report includes only the reptiles and amphibians of the riparian zone of the Grand Canyon.

2. Atwood, N. Duane; Pritchett, Clyde L.; Porter, Richard D., and Wood, Benjamin W. (United States Forest Service and others, Provo UT). Terrestrial vertebrate fauna of the Kaiparowits Basin [Offprint]. Great Basin Naturalist. 1980 Dec; 40(4):303-350.

Abstract: This report on the terrestrial vertebrate fauna is based on species reported in the literature and collections, and on field observations made by Brigham Young University personnel from 1971 to the fall of 1976. Report contains a bibliography and annotated field keys for amphibians and reptiles.

3. Bogan, Michael A., National Biological Survey Project Leader (US Geological Survey, Midcontinent Ecological Science Center, Department of Biology, University of New Mexico; Albuquerque Field Station). Research determines status and distribution of bats on the Colorado Plateau. Author unknown. Colorado Plateau; Quarterly Newsletter for Research and Resource Management of Colorado Plateau National Parks. 1994 Fall; 4(3):1, 6-7.

Abstract: Recent bat surveys using mist nets and ultrasonic call detectors have added considerably to knowledge of the bats present in national parks of the Colorado Plateau. Currently, 17 species are known, mainly year-round residents and all insectivorous. One other species found near the plateau is also likely. Protection of the bats and their habitat is dependent on gaining further information on summer habitat use and on the sites used for roosting during summer and/or winter. Recommendations are included for monitoring programs conducted by individual parks. Table 1 lists all the bats known from each of the 6 plateau parks surveyed, as well as from the Henry Mountains in Utah.

4. Bogan, Michael A. and Ramotnik, Cynthia A., University of New Mexico. Baseline surveys for mammals in four riparian areas in Glen Canyon National Recreation Area. Final report ed.; 1995 Jan 30 12 p.

Abstract: This reports an overall survey of mammals in and near Glen Canyon National Recreation Area, with emphasis in 1994 on distribution and abundance in riparian areas. The paper includes a preliminary list of Glen Canyon mammals (with notation of pertinent records) and a 1994 capture summary by location. The

effort added 4 bat species to those already known for the recreation area, and additional netting is expected to add some migratory species. A discussion of rodent captures notes the first capture of the Rock Pocket Mouse north of the San Juan River.

5. Chapter II: Description of the environment. Kaiparowits: Environmental Impact Statement. United States Department of the Interior; Final. 5 volumes.

Abstract: This detailed description of the Kaiparowits environment includes sections on reptiles and amphibians.

6. (also RABR). Clark, C. C. Report on the zoology of Navajo Mountain. Berkeley, CA; 1935; Project No. 3968-Y-1. 15 p. (Rainbow Bridge-Monument Valley Expedition, 1935).

Abstract: The annotated list of mammals, amphibians, reptiles, and birds represents collections and sightings by the author and several others in the vicinity of Rainbow Bridge on an expedition in 1935.

7. (also RABR). Cole, LaMont C. Report on the herpetology of the Navajo country. Rainbow Bridge-Monument Valley Expedition, 1935. 9 p.

Abstract: The annotated list of amphibians and reptiles represents collections by the author in northern Arizona and southern Utah on expeditions in 1934 and 1935. From August 2 to August 20, 1935, reptiles were collected in the neighborhood of Rainbow Bridge and Navajo Mountain.

8. Craig, Kelly A. and Pinnock, Clive A., Resource Management. Monitoring the Northern Leopard Frog (Rana pipiens) population at river mile -9.0 (Horseshoe Bend) on the Colorado River below the Glen Canyon Dam. Page, AZ: Glen Canyon National Recreation Area; 1995; Interim report. 30? p.

Abstract: A monitoring program was developed to produce needed baseline data, and to serve as a prototype for future amphibian studies in Glen Canyon National Recreation Area. Field observations from 1995 are discussed, along with recommendations for future study.

9. Drost, Charles A. and Sogge, Mark K. Survey of an isolated Northern Leopard Frog population along the Colorado River in Glen Canyon National Recreation Area. Flagstaff, AZ: National Park Service, Cooperative Park Studies Unit, Northern Arizona University; 1993; Northern Arizona University Report. 34 p.

Abstract: Survey results and management recommendations are included.

10. Eaton, Theodore H., Jr. Report on amphibians and reptiles of the Navajo country. Berkeley, CA: Rainbow Bridge-Monument Valley Expedition; 1935 Jun; Based upon field work with the Rainbow Bridge-Monument Valley Expedition during 1933. Bulletin 3. 20 p.

Abstract: The annotated list of amphibians and reptiles represents collections by the author in northern Arizona and southern Utah on a 1933 expedition.

11. Fotsch, Fred and Mollica, Joe, Students (Northern Arizona University). The 1992 Lizard Census of the Grand Canyon Riparian Corridor, Beus, Stanley S.; David, James N.; Stevens, Lawrence Edward, and Lojko, Frank B., Instructors. Colorado River Investigations, #XI. Flagstaff, AZ: Northern Arizona University; 1992 Nov 175 p.

Abstract: A census was made of the four major lizard species on selected beach sites, and other unusual reptiles were noted. The Tree Lizard was most often encountered, and the Side Blotched, least. Correlations were made to temperature and time of day.

12. Glen Canyon National Recreation Area. Checklist of mammals. 1998 Mar 2 p.

Abstract: List, primarily for visitors, of the mammals found at Glen Canyon National Recreation Area. The list, grouped by order, includes both common and scientific names.

13. Glen Canyon National Recreation Area. Checklist of reptiles and amphibians. 1997 Jul 1 p.

Abstract: List, primarily for visitors, of the amphibians and reptiles found at Glen Canyon National Recreation Area. The list includes both common and scientific names for 29 reptiles, along with 7 salamanders, toads, and frogs.

14. Hevly, Richard H.; Blinn, Dean W.; Gaud, William S.; States, Jack S.; Lipke, William G.; Aitchison, Stewart W. and others (Northern Arizona University, Department of Biological Sciences). Appendix C: Biotic studies. Preliminary biotic inventory and habitat description of the Kaiparowits Basin (15 February 1972). Kaiparowits project: environmental report, volume 2. Arizona Public Service Company; 1873 Jun 500? p., in various paginations.

Abstract: The preliminary biotic survey includes vascular and non-vascular plants, invertebrates (primarily insects), and vertebrates. Approximately 1357 taxa are now known for the Kaiparowits Basin, including 609 species which were collected for the first time in the basin as part of this study

15. Johnson, David W. (The College of Santa Fe, NM 87501). Desert buttes: natural experiments for testing theories of island biogeography [Offprint]. National Geographic Research. 1986; 2(2):p. 152-166.

Abstract: The animal inhabitants of five isolated buttes (and one non-isolated control butte) in the Glen Canyon National Recreation Area were investigated.

16. Kimberling, Diana, Principal investigator; Department of Biology, Northern Arizona University. Genetic comparisons among isolated populations of the northern leopard frog (Rana pipiens) in Arizona and Utah (proposal). 1994 Mar 22 10? p. + associated correspondence.

Abstract: Assume this includes genetic material from population within GLCA??

17. Laramie 82071. Biogeography of insects and amphibians of perennial stream riparian zones of Glen Canyon National Recreation Area. 1993; Proposal submitted to NPS. 17 p.

Abstract: The research would be a baseline survey of the major insect groups and amphibian species in these areas, and would allow distinguishing between hanging garden and riparian insect assemblages. >> Note: was this ever done?? <<

18. LaRue, Charles T. and Spence, John R., Resource Management Division, Glen Canyon National Recreation Area. Annotated checklist of the birds of Glen Canyon National Recreation Area, Utah and Arizona [draft]. 1999? 15 p.

Abstract: This checklist of birds found at Glen Canyon National Recreation Area includes annotations for a number of the species listed. The annotations briefly note observations (location, date, observers). They also generally characterize the abundance and status of that species in the area (example: "sparse transient"). The species are listed in alphabetical order within each family.

19. Mollhagen, Tony R. and Bogan, Michael A. Bats of the Henry Mountains region of southeastern Utah. Author unknown. Occasional Papers, Museum of Texas Tech University. 1997 Oct 1; 1701-13.

Abstract: This paper contains preliminary information from surveys of bats in Utah's Henry Mountains, just north and west of Lake Powell. The bats of this remote region had been little studied before this project began in 1993. The researchers confirmed 9 bat species additional to those known before for the region. The paper gives 18 short species accounts, and includes a table of captures by location for 15 species. Of the 3 not found, 2 are not likely, and the third is represented by a previous unconfirmed, but probable, record.

20. Mueller, Gordon; Boobar, Lewis; Wydoski, Richard; Comella, Kristen; Fridell, Richard, and Bradwisch, Quentin. Aquatic survey of the lower Escalante River, Glen Canyon National Recreation Area, Utah, June 22-26, 1998. United States Department of the Interior, Geological Survey; 1998?; Open-File Report 99-101. 37 p.

Abstract: The purpose of this lower Escalante River survey was "to begin gathering baseline biological information on the more remote sections of this unique watershed." The report's third main section gives amphibian results. Although 5 species were reported earlier, only the Woodhouse toad was found, possibly because the survey occurred at the end of the breeding season.

21. Murdock, Joseph R.; Allred, Dorald M., and Welsh, Stanley L. (Brigham Young University, Center for Health and Environmental Studies). Appendix C: Biotic studies. Baseline studies of plants, animals, and soils for Kaiparowits Generating Station: Nipple Creek access road, evaporation pond, conveyor route, Kaiparowits-El Dorado 500 KV corridor. Kaiparowits project: environmental report, volume 2. Arizona Public Service Company; 1973 Jun 500? p., in various paginations.

Abstract: This report includes the physiography of several parts of the Kaiparowits, vegetation, soils, animals and recommendations for further study. There are lists of the vertebrate and invertebrate animals collected or observed.

22. Murdock, Joseph R.; Welsh, Stanley L., and Wood, Benjamin W., Principal investigators. Navajo-Kaiparowits environmental baseline studies, chapter 1. Provo, UT : Center for Health and Environmental Studies, and Botany and Range Science Department, Brigham Young University; 1974?; Summary report, 1971-1974. 302 p.

Abstract: This is the first part of the summary collected studies by Brigham Young University scientists of the natural resources in areas likely to be affected by the Navajo and Kaiparowits coal-fired generating stations. It concentrates more on plant community and animal population studies in the northern part of the basin. Sections terrestrial vertebrate fauna of the Kaiparowits Basin. There are annotated checklists, and identifications of specimens collected.

23. Pendergast, Jeanne, Field Library Technician, Northern Arizona University: compiler. Fish list for Glen Canyon National Recreation Area. 2000 Jun 2 p.

Abstract: |In the absence of an official fish list, the compiler listed fish species mentioned in two current documents found at Glen Canyon National Recreation Area.

24. Spence, John R., Resource Management Division, Glen Canyon National Recreation Area. Special status terrestrial species and communities of Glen Canyon National Recreation Area. 1999 Aug 6 p.

Abstract: This list of special status species at Glen Canyon National Recreation Area includes a number of plants, some birds and mammals, and one each amphibian (Northern Leopard Frog) and reptile (Chuckwalla). The species are listed according to federal or state ranking, as well as to rarity within the recreation area. The list also includes plant communities that are rare within the recreation area. A separate list of plant species gives those little known from the area, but likely to be found more widespread as further research is done.

25. Spence, John R., Resource Management Division, Glen Canyon National Recreation Area. The controlled flood of 1996: effects on vegetation and leopard frogs (Rana pipiens) at RM -8.8L marsh, Colorado River, Glen Canyon [final report]. 1996 Dec 25 p.

Abstract: A population of northern leopard frogs (Rana pipiens) at a Colorado River marsh above Lees Ferry experienced relatively few changes as a result of the March-April 1996 controlled river flooding, according to this report. In addition to the frog-monitoring data, researchers collected information on habitat (vegetation cover and composition, water temperature, pH, dissolved oxygen, conductivity).

26. Spence, John R., Botanist, Glen Canyon National Recreation Area, National Park Service. Survey and describe the floristics and physical features of hanging gardens within Glen Canyon National Recreation Area (folder). 1995; Trip report.

Abstract: At present, the folder for this study contains only the report of a trip to areas along the Escalante Arm, August 15-17, 1995. The author and two others investigated hanging gardens at the upper end of the east fork of Iceberg Canyon, an unnamed canyon (called "Rana" in report), and two other areas. Unusual or rare plant and animal species are noted, apparently including leopard frogs??

27. Spence, John R. and Zimmerman, Julie A. C., Resource Management Division, Glen Canyon National Recreation Area. Preliminary flora of Glen Canyon National Recreation Area. 1996 Oct 23 p.

Abstract: This list of the flora of Glen Canyon National Recreation Area contains 745 species. The introduction mentions previous botanical work in the area, and notes (with locations) recent additions to this list and to a separate list of over 100 species found in areas adjacent to the park. Introduced species are marked with an asterisk.

28. Springer, Stewart. An Annotated List of the Lizards of Lees Ferry, Arizona. Copeia, A Journal of Cold-Blooded Vertebrates. 1928 Oct 25; 169(October-December):100-104.

Abstract: The annotated list includes a table of distribution of Lees Ferry lizards, showing that only one species is restricted to the region.

29. SWCA, Inc., Environmental Consultants. Monitoring and evaluating the impacts of Glen Canyon Dam interim flows on riparian communities in lower Grand Canyon. Final report and preliminary reports ed.. Flagstaff, AZ: SWCA, Inc.; 1995 Feb; Submitted to the Hualapai Tribe. 7 volumes. (United States Bureau of Reclamation, Glen Canyon Environmental Studies, Phase II).

Abstract: The final report (179 p.) provides comprehensive detail on the riparian communities in the lower Grand Canyon, and on the effects of Glen Canyon Dam operations. One section reports on reptile studies.

30. Tanner, Wilmer W. (Brigham Young University, Provo UT). Herpetology of Glen Canyon of the Upper Colorado River Basin [Offprint]. Herpetologica. 1958; 14193-195.

Abstract: This is a pre-dam list of reptiles and amphibians of the Glen Canyon area, with many of the observations from a time of relatively little human activity in this region. The records included are only those from the immediate river canyon and areas close to it, excluding the mountains and high plateaus in the vicinity. Many of the subspecies noted are endemic to the area. A footnote mentions Woodbury's list, but says it is incomplete (having only 19 of the 28 species and subspecies known), and some of the taxonomy is out of date.

31. Tanner, Wilmer W. and Heinrichs, J. W. (Department of Zoology, Brigham Young University, Prove UT; Page AZ). An extension of Arizona E. philipi and Rhinocheilus L. lecontei into southcentral Utah [Offprint (partial)]. The Southwestern Naturalist. 1964 Apr 10; 9(1): p. 45-6.

Abstract: The location of several Arizona elegans philipi (snakes) on the west side of the Colorado River near the Paria was unexpected, as the previously known populations in the area were on the east. The Rhinocheilus or long-nosed snakes found at Wahweap and another location represent an extension of their range eastward from the Virgin River drainage.

32. Warren, Peter L. and Schwalbe, Cecil R. Herpetofauna in Riparian Habitats along the Colorado River in Grand Canyon National Park. 1986 Aug; Final Report of Work Performed for the Glen Canyon Environmental Studies. 16 p.

Abstract: The study analyzed patterns of habitat use by reptile and amphibian species, and evaluated the relative importance of riparian habitats to specific aspects of reptile and amphibian foraging and reproduction. Lizard population densities and species composition were sampled in riparian and non-riparian habitats along the Colorado River.

33. Wildlife, GLCA, inventory, Kanab District (folder). later 20th century 1 file folder; Printed and typed material, computer printouts.

Abstract: The folder contains a Grand Canyon list of reptiles identified in the Kanab District; an 8-page typed animal checklist with Glen Canyon NRA locations and years of sightings.

34. Woodbury, Angus M. (Emeritus Professor of Zoology, Division of Biological Sciences). Amphibians and reptiles of Glen Canyon, [Reprint]. Ecological studies of flora and fauna in Glen Canyon, University of Utah Anthropological Papers No. 40. University of Utah; 1959 Jun; Article on pages 135-148. 225? p. (Glen Canyon Series; 7).

Abstract: Known records of amphibians and reptiles collected in Glen Canyon or adjacent tributaries have been compiled in this list. Some of the records are from expeditions of 1936-1938. This annotated list provides a historical record of pre-reservoir conditions and a basis for comparison with ensuing counts. Species list by order and family, and a short bibliography

35. Woodbury, Angus M.; Flowers, Seville; Lindsay, Delbert W.; Durrant, Stephen D.; Dean, Nowlan K.; Grundmann, Albert W.; Crook, James R.; Behle, William H.; Higgins, Harold G.; Smith, Gerald R.; Musser, Guy G., and McDonald, Donald B., Contributing authors; Division of Biological Sciences, University of Utah. Ecological studies of the flora and animals in Glen Canyon as a part of the Upper Colorado River Basin Salvage Program. Dibble, Charles E., Editor. Salt Lake City, UT: University of Utah Press; 1959 Jun; In accordance with the Memoranda of Agreement 14-10-333-215, 14-10-333-235, 14-10-333-429 between the United States National Park Service and the University of Utah. 230 p. (University of Utah Department of Anthropology, Anthropological Papers: Glen Canyon Series; 7 (40)).

Abstract: The study is based largely on field investigations during 1957-1958 (pre-inundation). One section covers amphibians and reptiles.

Grand Canyon National Park (GRCA)

1. Aitchison, Stewart W.; Carothers, Steven W.; Karpiscak, Martin M.; Theroux, Michael E., and Tomko, Dennis S. Amphibians and reptiles,from: Aitchison, Stewart W.; Carothers, Steven W.; Karpiscak, Martin M.; Theroux, Michael E., and Tomko, Dennis S., Contributors. An Ecological Survey of the Colorado River and its Tributaries between Lees Ferry and the Grand Wash Cliffs. Northern Arizona Society of Science and Art, Inc.; 1974 Dec; NPS Contract Nos. CX821040079 and CX821500007. 235 p.

Abstract: Photocopied list from the report includes only the reptiles and amphibians of the riparian zone of the Grand Canyon.

2. Atwood, N. Duane; Pritchett, Clyde L.; Porter, Richard D., and Wood, Benjamin W. (United States Forest Service and others, Provo UT). Terrestrial vertebrate fauna of the Kaiparowits Basin [Offprint]. Great Basin Naturalist. 1980 Dec; 40(4):303-350.

Abstract: This report on the terrestrial vertebrate fauna is based on species reported in the literature and collections, and on field observations made by Brigham Young University personnel from 1971 to the fall of 1976. The fauna of the Kaiparowits Basin is represented by 7 species of amphibians and 29 species of reptiles, 183 species of birds, and 74 species of mammals.

3. Brown, Nikolle.

4. Zoology Specimen Collection-Amphibians. 20th century 150? specimens.

Abstract: In 1993 the collection of amphibians consisted of about 150 specimens, mostly in jars of alcohol.

5. Zoology Specimen Collection-Reptiles. 20th century 325? specimens.

Abstract: In 1993 the collection of reptiles consisted of about 325 specimens, mostly in jars of alcohol.

6. Carothers, Steven W.; Aitchison, Stewart W. and others, Harold S. Colton Research Center, Museum of Northern Arizona. An Ecological Survey of the Riparian Zone of the Colorado River Between Lees Ferry and Grand Wash Cliffs. Flagstaff, AZ: Museum of Northern Arizona; 1976 Jun 30; GRCA Technical Report no. 10, Contract No. PX821500007. 251 p. (Colorado River Research Series (Contribution no. 38).

Abstract: This report contains the results of an ecological survey of the riparian zone of the Colorado River from Lees Ferry to Grand Wash Cliffs, June 1974 to June 1976. The purposes of the survey were to describe post-dam vegetational changes; prepare vegetation maps; and describe population densities, home ranges and demography of important vertebrates.

7. Dammann, A. E., Grand Canyon AZ. Some Notes on Sceloporus undulatus tristichus, Cope.Folder, Grand Canyon Amphibians & Reptiles. 1927 2 p.; Carbon copy.

Abstract: The observations of this Grand Canyon lizard include habitat, reproduction, measurements, and food. There is also a page of notes on the birth of 18 young from a specimen of Phrynosoma douglassii hernandesi, another Grand Canyon lizard ('horned toad').

8. Dickens, Joan L., Student (Northern Arizona University). A Comparison of Reptile Use of Old High Water Line Habitats Versus New High Water Line Habitats in the Grand Canyon, [Photocopy]. Beus, Stanley S. and Carothers, Steven W., Instructors. Colorado River Investigations IV. House, Dorothy A., Editor. Flagstaff, AZ: Northern Arizona University/Museum of Northern Arizona; 1985 Jun; Students and staff of Geology 538-626. 258 p.

Abstract: Contrary to expectations that reptile use of the two high water zones would be similar, the researchers found significantly higher use of the new high water zone, along with considerable movement between the two.

9. Dodge, Natt N. Amphibians and Reptiles of Grand Canyon National Park. Grand Canyon Natural History Association; 1938 Jul; Bulletin number 9. 55 p.

Abstract: This bulletin includes background information of the reptiles and amphibians of the canyon and a detailed annotated checklist with photographs.

10. Durham, Floyd E. (Hancock Foundation, University of Southern California, Los Angeles). Amphibians and Reptiles of the North Rim, Grand Canyon, Arizona [Offprint]. Herpetologica, Allan Hancock Foundation, Contribution 175. 1956; 12p. 220-224.

Abstract: The article describes a number of individual specimens the author captured on the North Rim, half of which were given to the Naturalists' Workshop, South Rim, Grand Canyon

11. Ebersole, Michael James, National Park Service, Grand Canyon National Park. Foot Survey, Eastern Grand Canyon Boundary. Grand Canyon, AZ: Grand Canyon National Park; 1976 Oct 26 114 p.

Abstract: The author walked the boundaries of the Desert View section of Grand Canyon National Park (over 13 miles) to be sure the lines in use by the park are accurate. The author includes natural history observations about reptiles.

12. Evans, Doug; Maxon, Jim, and Gale, Rick, Naturalists and ranger, Grand Canyon National Park. Reconnaissance of the Shivwits Plateau. 1969 Jul 25 p.

Abstract: The authors report on a ground and aerial survey of the Shivwits Plateau. The description of the natural setting includes biology (lists of reptiles.

13. (also GLCA). Fotsch, Fred and Mollica, Joe, Students (Northern Arizona University). The 1992 Lizard Census of the Grand Canyon Riparian Corridor, Beus, Stanley S.; David, James N.; Stevens, Lawrence Edward, and Lojko, Frank B., Instructors. Colorado River Investigations, #XI. Flagstaff, AZ: Northern Arizona University; 1992 Nov 175 p.

Abstract: A census was made of the four major lizard species on selected beach sites, and other unusual reptiles were noted. The Tree Lizard was most often encountered, and the Side Blotched, least. Correlations were made to temperature and time of day.

14. Garges, Patricia; Schwarz, Jean M.; Bonner, Shirley, and Adams, Doug, Students, Geology 538-626 (Northern Arizona University). Reptile study-1986, [Photocopy]. in: Beus, Stanley S. and Carothers, Steven W., Instructors. Colorado River Investigations V, July-August 1986. Weiss, Gayle C., SWCA, Environmental Consultants; editor. Flagstaff, AZ: Northern Arizona University/Museum of Northern Arizona; 1987 Mar; Submitted to Mr. Richard W. Marks, Superintendent, Grand Canyon National Park, Grand Canyon, Arizona. 190 p.

Abstract: The New High Water Line (NHWL) vegetation, mostly tamarisks (salt cedars), was thought to have little value as animal habitat. Recent studies show, however, that it is not only used by native reptiles, but may be preferred. Reptile densities in four zones on various beaches were tabulated, and also temperatures measured for possible correlation.

15. Gehlbach, Frederick R. (Baylor University). Determination of the relationships of tiger salamander larval populations to different stages of pond succession at the Grand Canyon, Arizona [Reprint]. Year Book of the American Philosophical Society, 1969. 1969; p. 299-302.

Abstract: Early stage ponds on the Grand Canyon rims were found to support more tiger salamander larvae than later stage ponds did. The study was to determine possible regulatory factors.

16. Gehlbach, Frederick R.; Kimmel, James Ross, and Weems, William A., Department of Biology (Baylor University, Waco TX 76703). Aggregations and Body Water Relations in Tiger Salamanders (Ambystoma tigrinum) from the Grand Canyon Rims, Arizona [Reprint]. Physiological Zoology. 1969 Apr; 42(2):p. 173-182.

Abstract: The study is an attempt to understand the ecological significance of aggregations and coiling behavior in Grand Canyon tiger salamanders. A number of individuals were found collected together under logs and boards, and the behavior is apparently related to retaining body moisture when dampness becomes localized.

17. Hansen, R. M. for GRCA db. Dietary of the chuckwalla, Sauromalus obesus, determined by dung analysis. Herpetologica. 1974 Jun; 30(120-123).

Abstract: Botanical composition of the annual diet of the chuckwalla lizard was determined in the western end of the Grand Canyon.

18. Janda, Jodee and Jones, Carolyn, Students (Northern Arizona University). Lizard Diets and Density in the Riparian Zone of the Colorado River, Grand Canyon National Park, Beus, Stanley S.; Stevens, Lawrence Edward, and Lojko, Frank B., Instructors. Colorado River Investigations, #10. Flagstaff, AZ: Northern Arizona University; 1991 Dec 127 p.

Abstract: Lizard diet analysis revealed that lizards eat significant amounts of river-derived aquatic invertebrates. Data gathered on lizard densities show that numbers decrease with distance downstream.

19. Klauber, Lawrence M. New and Renamed Subspecies of Crotalus confluentus say, with Remarks on Related Species. Transactions of the San Diego Society of Natural History. 1930 Feb 8; VI(3):95-144.

Abstract: A section of the report containing a detailed description of the Grand Canyon (Pink) Rattlesnake, along with its range and a tentative subspecies key.

20. Lew, Mable and Welden, Amy, Students (Northern Arizona University). Lizard Distribution and Density Studies along the Colorado River in Grand Canyon National Park, Beus, Stanley S.; Stevens, Lawrence Edward, and Lojko, Frank B., Instructors. Colorado River Investigations, #9. Flagstaff, AZ: Northern Arizona University; 1991 Jan 174 p.

Abstract: Lizard distribution and density data was analyzed according to zone, and significant differences were found. A higher percentage of lizard species and density was found in Zone 4 (of four zones), which was comprised of a greater percentage of shrub and ground cover as well as insect richness.

21. McKee, Edwin D., Park Naturalist, Grand Canyon National Park. Report on Reconnaissance Trip to Grand Canyon National Monument, Arizona. 1934 Apr 9 p.

Abstract: The trip was to make general observations, studies and collections of the biological and geological features of the area. 'Fauna' lists reptiles discovered in different areas.

22. McKee, Edwin D. The type specimen of the Grand Canyon Rattlesnake. 1975 4 p.

Abstract: The author describes the finding, live collection and transport of the first Grand Canyon Pink Rattlesnake in 1929.

23. Miller, Donald M. (Southern Illinois University, Carbondale IL 62901). Interim Report on 'Molecular Heterogeneity of Venoms, Blood Proteins, and Spinal Fluid from subspecies of the Prairie Rattlesnake (Crotalus viridis), [Photocopy]. 1979? 3 p.

Abstract: A comparative study was being done of venoms of at least four subspecies of Crotalus viridis. Other associated publications are as follows: Young, R. A., D. M. Miller and D. C. Ochsner. 'Venoms of Subspecies of the Prairie Rattlesnake Compared to that of the Grand Canyon Rattlesnake'. Amer. Zool. 18(3):634. Abst #376; 'Venom of Grand Canyon Rattlesnakes and Related Species'. Paper submitted to Conf. on Research in National Parks, San Francisco, CA 26-30 Nov 1979.

24. Miller, Donald M.; Young, Robert A.; Gatlin, Thomas W., and Richardson, John A. Amphibians and Reptiles of the Grand Canyon. Grand Canyon, AZ: Grand Canyon Natural History Association; 1982; 143 p. (Monograph No. 4. ISBN: 0-938216-17-1.

Abstract: This is an in-depth annotated checklist of the reptiles and amphibians of the Grand Canyon.

25. Olsen, T. G.; Sharp, Marion M.; Dancis, Dale; Benson, A., and Perry, L., Students (Northern Arizona University). Terrestrial Vertebrate use of Woody Riparian Vegetation in Colorado Rim Habitats, [Photocopy]. Beus, Stanley S. and Carothers, Steven W., Instructors. Colorado River Investigations I. Flagstaff, AZ: Northern Arizona University/Museum of Northern Arizona; 1982 Dec; Students and staff of Biology 571-Geology 538. 131 p.

Abstract: Salt cedar, willow and mesquite were studied for diurnal vertebrates, and based on the limited sampling, the exotic salt cedar appears to be more used by reptiles and birds than the two native species.

26. Rasmussen, D. Irvin, Doctoral candidate (University of Illinois). Biotic Communities of Kaibab Plateau, Arizona [Photocopy]. Ecological Monographs. 1941 Jul; 11(3):230-275.

Abstract: Lists of amphibians and reptiles.

27. Sherbrooke, Wade C. Ecologic Distribution of the Amphibians and Reptiles of the Mt. Trumbull-Toroweap Valley Region of Northern Arizona [Photocopy]. Tucson, AZ: M.S. Thesis, University of Arizona; 1966 70 p.

Abstract: The primary objective of the investigation was the determination of the ecologic distribution of the amphibians and reptiles studied. The characteristics and vegetation of the region are described and fauna distribution correlated with biotic communities.

28. Stevens, Lawrence Edward. The Colorado River in Grand Canyon: A guide. Flagstaff, AZ: Red Lake Books; 1983; 110 p. ISBN: 0-9611678-6-6.

Abstract: The guide contains mile-by-mile river maps, and has considerable information about Grand Canyon weather and climate, geology, biology and ecology (along with human history, Glen Canyon Dam and its effects, etc.). The revised editions contain updates on species only recently observed at Grand Canyon for the first time, such as certain reptiles in the mid-1990's.

29. Suttkus, Royal D.; Clemmer, Glenn H.; Jones, Clyde, and Shoop, C. Robert. Survey of Fishes, Mammals and Herpetofauna of the Colorado River and Adjacent Riparian Areas of the Grand Canyon National Park. 1976 Dec; Contract No. CX821060006. 6 p.

Abstract: This report from the Transition Period of July 1, 1976 to September 30, 1976 lists the results from a single float trip. The authors took 27 reptiles and amphibian specimens. Other amphibians and reptiles were captured, examined, and released at the site.

30. Tanner, Wilmer W. (Provo High School, Provo UT). A taxonomic study of the genus Hypsiglena [Microfiche]. The Great Basin Naturalist. 1944 Dec 29; V(3 & 4):p. 25-92.

Abstract: The article contains descriptions of various members of the genus *Hypsiglena*, including at least one whose type specimen was found in Grand Canyon National Park.

31. Tomko, Dennis S., Museum of Northern Arizona, Flagstaff . An ecological study of Grand Canyon lizards. Tomko, Dennis S. and Kreigh, Steve A., Compilers; 1976 Aug; Final Report. Prepared for and sponsored by the Grand Canyon Natural History Association. 27 p.

Abstract: Rather than just describing collections, this report combines field data and published information to elaborate the diet and interrelationships of five Grand Canyon lizard species. Most of the lizards were found near the Colorado River in the tamarisk-willow area. Demography of three of the species is discussed in more detail. Along with various facets of lizard diets, the study investigated the timing of reproductive cycles and aspects of predation.

32. Tomko, Dennis S., Museum of Northern Arizona, Flagstaff. The reptiles and amphibians of the Grand Canyon. Plateau, The Quarterly of the Museum of Northern Arizona. 1975 Spring; 47(4):161-166; ISSN: 0032-1346.

Abstract: The reptile and amphibian checklist has been updated with the addition of nine species, bringing the total to 41. In addition to details on those nine, the article discusses the taxonomic status of three species, and a new checklist is included.

33. Tomko, Dennis S. and Theroux, Michael E., Compilers, submitted by Carothers, Steven W., Curator of Zoology, MNA. An Ecological Survey (Vascular Flora and Vertebrate Fauna) of the Riparian Zone of the Colorado River and its Tributaries Between Lees Ferry and the Grand Wash Cliffs (period ending 1 December 1973). 1973 Dec 4; Project #CX821040079. 13 p.

Abstract: This report summarizes a flora and fauna survey of the riparian zone of the Colorado River corridor in the fall of 1973.

34. Warren, Peter L. and Schwalbe, Cecil R., co-authors. Herpetofauna in riparian habitats along the Colorado River in Grand Canyon [photocopy]Johnson, R. Roy; Ziebell, Charles D.; Patton, David R.; Ffolliott, Peter F., and Hamre, R. H., Technical coordinators. Riparian ecosystems and their management: reconciling conflicting uses; First North American Riparian Conference; Tucson, AZ. Fort Collins, CO: Rocky Mountain Forest and Range Experiment Station; 1985: 347-354. 523 p.

Abstract: Lizard population densities and species composition were sampled in riparian and non-riparian habitats along the Colorado River. The highest densities were found in shoreline habitats, moderate densities in

riparian habitats and lowest densities in non-riparian habitats. Rapidly fluctuating river flow levels may have a deleterious effect on lizard populations by trapping populations on alluvial sandbars and inundating nest sites.

35. Young, Robert A. and Miller, Donald M. (Southern Illinois University, Carbondale IL 62901). Notes on the Natural History of the Grand Canyon Rattlesnake (Crotalus viridis abyssus Klauber). Bull. Chi. Herp. Soc. 1981?; 15(1):1-5.

Abstract: The report discusses the range and distribution, characteristics, and habits of the Grand Canyon pink rattlesnake. Consensus among frequent hikers and others is that most of these snakes are amiable, and not usually a threat to visitors within the canyon. (In the one report of a bite mentioned, the person put a hand right on the snake while climbing. He recovered.) Relationships with other subspecies are discussed.

Hubbell Trading Post National Historic Site (HUTR)

1. Gandhi, Kancheepuram N. Vegetation Survey on Hubbell Trading Post, National Historic Site, Ganado, Arizona. 1987? 11 pages.

Abstract: List of vegetation and where this vegetation is located at the Trading Post. The list indicates which plants were introduced and naturalized, and which plants were cultivated.

2. Gandhi, Kancheepuram N. and Hatch, Stephan L. A checklist of the vascular plants of Hubbell Trading Post National Historic Site, Ganado, Arizona . Phytologia. 1987 May; 62(6):487-494.

Abstract: The checklist of Hubbell Trading Post vascular flora includes 130 species and varieties identified by the authors in a 1986 survey. Information is included on the nativity of the plants (native, or introduced but naturalized; cultivated plants found during the study are not included on this list).

3. Pendergast, Jeanne, Field Library Technician, Northern Arizona University: compiler. Plant list for Hubbell Trading Post. 2000 Jun 2 p.

Abstract: |In the absence of an official plant list for Hubbell Trading Post National Historic Site, the compiler listed plant species mentioned in two current documents sent by the site's resource manager.

Mesa Verde National Park (MEVE)

1. Author unknown? (no author included in original record). Amphibian Decline. 1991 Sep 17 8 p.

Abstract: Cover of this is a memorandum to Regional Director, Rocky Mountain Region from Superintendent, Mesa Verde that includes amphibian records from Mesa Verde and adjacent areas, as well as citations concerning other amphibian surveys and studies. One list is amphibian sightings from 1984 - 1989 that includes Bufo woodhousei, Bufo punctatus, Scaphiopus, leopard frog, Pseudacris triseriata, Rana catesbeiana, and Ambystoma tigrinum. Results of amphibian survey from 1990 are included.

2. Author unknown? (no author included in original record). Annual report for the Division of Research and Resource Management. Mesa Verde National Park, CO; 1993 Mar 2 50 p.

Abstract: This report includes a section on Natural Resource Management. Faunal projects were listed that included amphibian sightings. Total faunal observations for 1992 numbered 3430 reports of birds, mammals, amphibians, reptiles, and invertebrates.

3. Author unknown (or not included when record was created). DOR Fauna. 1989 18 p.

Abstract: Descriptions of animals found dead on the road. Species include rattlesnakes and striped whipsnakes. Date of find, age, sex, location and comments are included for each species.

4. Barry, Lewis T. Collared lizards and utas of Mesa Verde . Mesa Verde Notes. 1932 Aug; Volume III, Number 2page 21.

Abstract: Narrative description of behavior of collared lizard and two species of Utas. Line drawing of collared lizard.

5. Barry, Lewis T. Herpetological note. 1932 Jul 1 1 page. (COPEIA (1932, No.2)).

Abstract: Notation of Hypsiglena ochrorhynchus found dead on Mesa Verde Park road by Donald Watson.

6. Bogan, Michael A., Wildlife Research Biologist, U.S. Fish and Wildlife Service. Annual report: biological surveys in four national parks, 1989. 1990 Jan 16 7 p.

Abstract: Pages 3-4 of the report describe the work done at Mesa Verde National Park. The author's crew surveyed Morefield and Prater canyons, Long Mesa, and Wetherill Mesa for small mammals. Also included is an updated list of mammals for Mesa Verde.

7. Bogan, Michael A. Annual report: biological surveys in four national parks, 1990. 1991 Feb 12 19+ p.

Abstract: Briefly describes status of biological surveys in four national parks on the Colorado Plateau. Pages 2 and 3 summarize 1990 work at Mesa Verde National Park, noting that 8 species from 1989 were not captured the next year, but 6 additional species were. Additional pages after the summaries include the 1990 Mesa Verde capture summary by location.

8. Bogan, Michael A. Annual report: biological surveys in five national parks, 1991. 1992 Jan 14 25+ p.

Abstract: Briefly describes status of biological surveys in five national parks. Page 4 summarizes 1991 work at Mesa Verde National Park, noting particularly the first park captures of two bat species (big brown bat and hoary bat). Additional pages after the summaries include a preliminary list of mammals of the park (with pertinent references), and the 1991 capture summary by location.

9. Bogan, Michael A., U. S. Fish and Wildlife Service. Baseline inventories of mammals in Colorado Plateau national parks and monuments: Investigator's Annual Report. 1993 Apr 21 14 p.

Abstract: Investigator's Annual Report 1992. A field crew from Fish and Wildlife consisting of 2-3 biologists, conducted field studies at MEVE from August 25 to September 7. Efforts in 1992 were focused on collecting baseline data from areas not previously covered, including Step House, Mug House, Long house, low elevation areas near park entrance, the upper end of Mancos Canyon, and bat netting in Morefield, Spruce Tree, and Navajo canyons. A draft list and capture summaries for amphibians, and reptiles during 1992 was prepared.

10. Bogan, Michael A. Research determines status and distribution of bats on the Colorado Plateau. Colorado Plateau; Quarterly Newsletter for Research and Resource Management of Colorado Plateau National Parks. 1994 Fall; 4(3):1, 6-7.

Abstract: Recent bat surveys using mist nets and ultrasonic call detectors have added considerably to knowledge of the bats present in national parks of the Colorado Plateau. Currently, 17 species are known, mainly year-round residents and all insectivorous. One other species found near the plateau is also likely. Protection of the bats and their habitat is dependent on gaining further information on summer habitat use and on the sites used for roosting during summer and/or winter. Recommendations are included for monitoring programs conducted by individual parks. Table 1 lists all the bats known from each of the 6 plateau parks surveyed, as well as from the Henry Mountains in Utah.

11. Bogan, Michael A. and Ramotnik, Cindy A., National Ecology Research Center, U.S. Fish and Wildlife Service. Annual report: biological surveys on Colorado Plateau national parks, with updated lists of mammals from the parks and mammal capture summaries for 1992. 1993 Feb 18 30+ p.

Abstract: Pages 4-6 of the report describe biological survey work done at Mesa Verde National Park in the fourth field season of an ongoing investigation. In addition to bats, the authors surveyed for woodrats and other small mammals at a number of locations not sampled before. Further sampling is recommended for some of these. Additional pages include an updated list of mammals thought to occur in the park (with pertinent references), and the 1992 capture list by location (mostly mammals, but also including 3 birds and 3 snakes.)

12. Cary, Merritt. A biological survey of Colorado. Washington, D.C.: Government Printing Office, U.S. Department of Agriculture, Bureau of Biological Survey; 1911 Aug 17; 246 p. (North American Fauna; v. Number 33).

Abstract: A report on the results of a biological survey of Colorado. Consists of three sections. The first characterizes the five life zones of the state, defines their extent and limits. The second consists of a complete list of mammals of Colorado with descriptions of habit and distribution. The third is a list of principal trees and shrubs. Mesa Verde is represented in all three areas.

13. Colyer, Marilyn A., Park Ranger. Amphibian survey . 1989 Nov 15 59 p.

Abstract: Reply to request from Mr. Geoffrey A. Hammerson, Univerisity of Colorado Museum for an amphibian survey. Daily summaries of sightings of Tiger Salamander, Woodhouse Toad, Striped Chorus Frog, and Wood Frog in and around Mesa Verde National Park. Date observed, location, habitat, description, snout-vent length and behavior are recorded.

14. Colyer, Marilyn A. Amphibian survey. 1991 18 p.

Abstract: Raw data sheets of amphibian survey done April through September of 1991. Documented species are chorus frog, woodhouse toad. Stage, site and location are also recorded.

15. Douglas, Charles L. Amphibians and Reptiles of Mesa Verde National Park, Colorado. University of Kansas Publications Museum of Natural History. 1966 Mar 7; 15(No. 15):pages 711-744.

Abstract: This reptile and amphibian study was part of the Wetherill Mesa Archeological Project. Narrative descriptions for each species are included as well as the number of species examined and location found. There is also a discussion of a species of unverified occurrence, Hammond's spadefoot toad.

16. M'Closkey, Robert T., Associate Professor, Department of Biological Sciences, University of Windsor, Ontario, Canada. Abundance and diversity of lizards at Mesa Verde National Park. 1991 Feb 5 p.

Abstract: Goals of project were to examine the possible effects of the Long Mesa burn on lizard abundance and species composition; to examine the recovery of lizard species at selected burn sites; to compare lizard numbers and diversity with unburned "control" sites; to document juvenile recruitment on burn sites; to monitor lizard recovery for at least 5 years.

17. M'Closkey, Robert T., Associate Professor, Department of Biological Sciences, University of Windsor. Abundance and diversity of lizards at Mesa Verde National Park: Habitat distribution and the effects of disturbance by fire. 1990 5 p.

Abstract: This research proposal details a study to investigate the relationship between lizard numbers, distribution, species diversity and species composition in regards to disturbance by fires. << Note: was this ever done? >>

18. Moody, Melvin A., Park V.I.P. Observation and Study of the Development of the Woodhouse's Toad, Bufo woodhousii from the Tadpole Stage through the Metamorphosis into the Toad StageMesa Verde Natural Resources Field Projects. 1985 20 pages; 1 hand-written bound journal.

Abstract: This field journal contains notes regarding tadpole development; including dates, numbers seen, stage of development, and any additional information.

19. Quaintance, Chas. W., Naturalist Assistant. Naturalist Assistant's Report March 15 to April 15, 1935. 1935 Apr 17 5 p.

Abstract: Narrative of biological observations by Wildlife Technician Quaintance. Description of field work. A listing and narrative of observations including reptiles.

20. Quaintance, Chas. W., Resident Wildlife Technician. Report of Resident Wildlife Technician for the period from June 15 to July 17, 1935. 1935 Jul 17 14 p.

Abstract: Narrative of biological observations by Wildlife Technician Quaintance and Lloyd White. Description of field work. A listing and narrative of observations of amphibians and reptiles.

21. Quaintance, Chas. W., Resident Wildlife Technician. Report of Resident Wildlife Technician for the period from May 15 to June 15, 1935. 1935 Jun 15 6 p.

Abstract: Narrative of biological observations by Wildlife Technician Quaintance Description of field work. A listing and narrative of observations of amphibians and reptiles.

22. Quaintance, Chas. W., Resident Wildlife Technician. Report of Resident Wildlife Technician Report on Activities April 15 to May 15, 1935. 1935 May 15 7 p.

Abstract: Narrative of biological observations by Wildlife Technician Quaintance. Description of field work. A listing and narrative of observations of reptiles and amphibians.

23. Ramotnik, Cynthia A. and Bogan, Michael A., US Geological Survey, Midcontinent Ecological Science Center, Department of Biology, University of New Mexico. Baseline surveys for mammals at Mesa Verde National Park, Colorado. 1995 Feb 7 11 p.

Abstract: The authors have conducted baseline surveys of mammals at Mesa Verde National Park since 1989. They captured bats with mist nets, and sampled ground foraging mammals with snap traps and live traps. Medium sized mammals were collected with firearms, and sightings of large mammals recorded. The survey was particularly successful in capturing shrews, allowing verification of 4 of the 5 known species. For bats, the survey provided new information, and the authors captured 11 of 16 known or suspected species. The report includes a narrative of areas surveyed plus a capture summary by location. There is also a preliminary list of Mesa Verde mammals (with notation of pertinent records).

24. Watson, Don. Park Naturalist's Monthly Narrative Report. Mesa Verde National Park, CO; 1940 Jan 50 p.

Abstract: Most reports have a section marked Botany or Zoology. Listed here are unusual observations of wildlife. Often it is a sighting not documented in that particular area previously.

25. Watson, Don. Report of the Park Naturalist. Mesa Verde National Park, CO; 1946 Jan 100 p.

Abstract: Reports have a section marked Wildlife, Wildlife Research or Research and Observation. Listed here are unusual observations of wildlife.

26. Watson, Don and Ross Kenneth I. Park Naturalist's Monthly Narrative Report. Mesa Verde National Park, CO; 1941 Jan 140 p.

Abstract: Each report has a section marked Botany or Zoology. Listed here are unusual observations of wildlife.

Navajo National Monument (NAVA)

1. Brotherson, Jack D. and Fairchild, John A. Ecological Studies at Navajo National Monument, Part I. National Park Service, Southwest Region; 1977 Nov 6 100+ p.

Abstract: Checklists of reptiles and amphibians.

2. Cole, LaMont C. Rainbow Bridge Monument Valley Expedition 1935: Report on the Herpetology of the Navajo Country; 1935; 9 p.

Abstract: Description of reptiles and amphibians found during this expedition (which included areas in Navajo National Monument).

3. Drost, Charles A. Inventory of threatened, endangered, and candidate species at Navajo National Monument. Flagstaff AZ: US Geological Survey Forest and Rangeland Ecosystem Science Center, Colorado Plateau Field Station; 2000 Jan 76 p.

Abstract: This paper reports results of a thorough survey at Navajo National Monument, with specific target species based on various indications of potential rare plants and animals in that area. The report gives detailed descriptions of species found; some of these are new for the area or state. The author also explains the effort made in searching for those not found, in support of listing some species as absent. Includes management recommendations, and outlines for population monitoring of the alcove bog-orchid and Mexican Spotted Owl. Among the 4 appendices is a list of the potential species sought, along with detailed field notes listing species by location, weather and other conditions, comments about individuals captured.

4. Woodbury, Angus M. Biological-Ecological Aspects of Betatakin Canyon Navajo National Monument Arizona. Institute of Environmental Biological Research, University of Utah Division of Biological Sciences; 1963 Jun 56 p.(Miscellaneous Papers; Number 2).

Abstract: Short report full of information. Lists of amphibia and reptiles.

Petrified Forest National Park (PEFO)

1. Cockrum, E. Lendell. Mammals of the Petrified Forest National Park: a reference manual. 1986 167 p.

Abstract: Summary species accounts of the mammals of Petrified Forest National Park, AZ. Includes North American distribution map and Park voucher map per species. No species or habitat illustrations. Common name index also serves as checklist.

2. Drost, Charles A., Erika M. Nowak, and Trevor B. Persons. 2000 unpubl. Inventory and monitoring methods for amphibians and reptiles at Petrified Forest National Park, Arizona. Final report to Petrified Forest National Park by USGS Biological Resources Division, Forest and Rangelands Ecosystem Science Center Colorado Plateau Field Station, Flagstaff, AZ.

3. Drost, Charles A.; Nowak, Erika, and Persons, Trevor. Inventory and monitoring methods for amphibians and reptiles at Petrified Forest National Park, Arizona. Flagstaff, AZ: US Geological Survey Forest and Rangeland Ecosystem Science Center, Colorado Plateau Field Station; 1999 May 69 p.

Abstract: Among the results of this 1997-1998 study of amphibians and reptiles is the discovery of two lizard species, the Little Striped Whiptail Lizard and the New Mexico Whiptail Lizard, which are new to Petrified Forest National Park and to the area. The study was designed to provide baseline information on the herpetofauna of an important section of remnant native grassland. The authors used a number of methods to capture over 1500 animals, finding that night driving surveys produced the best results with snakes and amphibians. For lizards, most observations were divided among those found through time-constrained searches, in pitfall traps, by general surveys, and in random encounters. (Appendix A gives capture rate by method for each species.) A list on page 16 identifies the 23 species found; three on older lists are either misidentified or probably no longer present. The report discusses status, habitat associations, biogeographic origins, relative abundance, and road mortality, with tables and graphs. It also gives management recommendations for protection, monitoring, and specific additional study. Among the recommendations is closure of park roads at night to prevent mortality, especially of snakes. There is also a section regarding species of concern to management. Species accounts (for both observed and hypothetical species) and additional observation data are in appendices B through F.

4. Hansen, M.; West, P., and Thomas, Kathryn. Vegetation of Petrified Forest National Park, Arizona, Part II: Revised checklist of the flora of the park [In review]. Flagstaff AZ: US Geological Survey and the Colorado Plateau Field Station; 2000 Jul 430+ species.

Abstract: In addition to a plant list for Petrified Forest National Park with 436 entries, the Access database containing the information in its current form includes a number of other tables and reports. A separate table and reports concerning exotics list 58 taxa; (these are also included in the main list). The main reports (one formulated as an appendix) are annotated, and include voucher numbers and dates, along with a listing of information sources. Other tables provide details on habit and on herbarium specimens.

5. Persons, Trevor and John W. Wright. 1999. Discovery of *Cnemidophorus neomexicanus* in Arizona. Herpetological Review 30(4): 207-208.

6. Persons, Trevor and John W. Wright. 1999. Geographic distribution: *Cnemidophorus inornatus*. Herpetological Review 30(2): 109.

7. Ramotnik, Cynthia A. and Bogan, Michael A., US Geological Survey, Midcontinent Ecological Science Center, Department of Biology, University of New Mexico. Baseline surveys for mammals at Petrified Forest National Park, Arizona: final report of 1996-1997 activities. 1998 Apr 22 21 p.

Abstract: The authors conducted baseline surveys of mammals at Petrified Forest National Park during 1996-1997. They captured bats with mist nets, and sampled ground foraging mammals with snap traps and live traps. Occasional specimens were salvaged along the roads, and tracks or scat of larger mammals recorded. The report briefly describes sampling locations and gives annotated species accounts for mammals captured or observed in the park. It also includes a capture summary by location and a preliminary list of Petrified Forest mammals (with notation of the 8 bat species recognized as C2 Species of Concern).

Petroglyph National Monument (PETR)

none.

Rainbow Bridge National Monument (RABR)

1. (also GLCA). Clark, C. C. Report on the zoology of Navajo Mountain. Berkeley, CA; 1935; Project No. 3968-Y-1. 15 p. (Rainbow Bridge-Monument Valley Expedition, 1935).

Abstract: The annotated list of mammals, amphibians and reptiles represents collections and sightings by the author and several others in the vicinity of Rainbow Bridge on an expedition in 1935.

2. (also GLCA). Cole, LaMont C. Report on the herpetology of the Navajo country. Rainbow Bridge-Monument Valley Expedition, 1935. 9 p.

Abstract: The annotated list of amphibians and reptiles represents collections by the author in northern Arizona and southern Utah on expeditions in 1934 and 1935. From August 2 to August 20, 1935, reptiles were collected in the neighborhood of Rainbow Bridge and Navajo Mountain.

3. (also GLCA and NAVA). Eaton, Theodore H., Jr. Report on amphibians and reptiles of the Navajo country. Berkeley, CA: Rainbow Bridge-Monument Valley Expedition; 1935 Jun; Based upon field work with the Rainbow Bridge-Monument Valley Expedition during 1933. Bulletin 3. 20 p.

Abstract: The annotated list of amphibians and reptiles represents collections by the author in northern Arizona and southern Utah on a 1933 expedition.

Salinus Pueblo Missions National Monument (SAPU)

1. Howell, Channing T. The Prairie Rattlesnake at Gran Quivira National Monument, New Mexico. Bulletin of the Southern California Academy of Sciences. 1957; 55(2):97-98.

Abstract: Description of the frequency of contact/observations of prairie rattlesnakes in a 4 acres region of Gran Quivira National Monument.

Sunset Crater Volcano National Monument (SUCR)

1. (also WUPA). Bateman, Gary C. (Department of Biology, Northern Arizona University, Flagstaff, Arizona). Amphibians and Reptiles. In: Natural Resource Survey and Analysis of Sunset Crater and Wupatki National Monuments, Final Report (Phase III), January 1980. 1980 Jan. IV-1 to IV-24.

Abstract: This report details the methods, results, and conclusions of amphibian and reptile research conducted at Wupatki and Sunset Crater. This survey identified species found in the different vegetative zones and attempted to understand the relationship between the herpetofauna and the plants and insects of the monuments.

2. (also WUPA). Bateman, Gary C. Amphibians and Reptiles of Sunset Crater and Wupatki National Monuments. 1976 Feb 3 p.; Checklist.

Abstract: Document consists of a listing of amphibians and reptiles found at Wupatki and Sunset Crater.

3. Rominger, James M. A Checklist of the Vascular Plants of Wupatki and Sunset Crater National Monuments. 1976 Feb 25 15 p.; Checklist.

Abstract: This checklist of the vascular plants of Wupatki and Sunset Crater includes four new families and 23 new genera that were previously unrecorded for this area.

Walnut Canyon National Monument (WACA)

1. Author unknown. A Floristic Checklist of Walnut Canyon, Arizona. 197? 15 p.

Abstract: Provides a history of flora checklist development at Walnut Canyon, followed by a new list.

2. Joyce, John Frederick. A Checklist of Plants: Walnut Canyon National Monument. 1998:10 pages.

Abstract: Based on a 1974 thesis by J. F. Joyce at NAU and revised by park staff.

3. Joyce, J. F. Vegetation analysis of Walnut Canyon, Arizona. Journal of the Arizona Academy of Science. 1976; 11(180):127-133.

Abstract: "A habitat for four distinct zones of differing vegetation is provided by the configuration of the canyon bottom and the north and south slopes and rims being in such close proximity. It was these distinct unnamed vegetation zones and the much outdated floristic checklists that prompted this taxonomic, vegetation and microclimate analysis of Walnut Canyon." Primarily scientific name checklist. Describes biotic communities.

4. Persons, T., and G. Bradley. 2000. Geographic distribution: *Diadophis punctatus*. Herpetological Review 31(2): 113-114.

Wupatki National Monument (WUPA)

1. Bateman, Gary C. (Department of Biology, Northern Arizona University, Flagstaff, Arizona). Amphibians and Reptiles. In: Natural Resource Survey and Analysis of Sunset Crater and Wupatki National Monuments, Final Report (Phase III), January 1980. 1980 Jan. IV-1 to IV-24.

Abstract: This report details the methods, results, and conclusions of amphibian and reptile research conducted at Wupatki and Sunset Crater. This survey identified species found in the different vegetative zones and attempted to understand the relationship between the herpetofauna and the plants and insects of the monuments.

2. Bateman, Gary C. Amphibians and Reptiles of Sunset Crater and Wupatki National Monuments. 1976 Feb 3 p.; Checklist.

Abstract: Document consists of a listing of amphibians and reptiles found at Wupatki and Sunset Crater.

3. Bergeson, Brian. Reptiles of Wupatki National Monument. date unknown 2 p.

Abstract: This report describes the appearance and feeding patterns of several reptiles located within Wupatki National Monument. The following page contains a checklist of reptiles and amphibians for both Sunset Crater and Wupatki National Monuments.

4. (also GLCA, GRCA, HUTR, PEFO, NAVA, RABR, SUCR, WACA). Fowlie, Jack A. The Snakes of Arizona. Fallbrook, Calif.; 1965.

Abstract: Letter and a few pages from book. Lists snake specimens taken from on or near Arizona National Parks and Monuments, includes pages pertinent to Wupatki.

5. Persons, Trevor. Persons, T. 1999. Geographic distribution: Sonora semiannulata. Herpetological Review 30(1): 55.

6. Persons, Trevor. 1999 unpubl. Road Mortality of Amphibians and Reptiles at Wupatki National Monument. Investigator's Annual Report to Wupatki National Monument.

7. Rominger, James M. A Checklist of the Vascular Plants of Wupatki and Sunset Crater National Monuments. 1976 Feb 25 15 p.; Checklist.

Abstract: This checklist of the vascular plants of Wupatki and Sunset Crater includes four new families and 23 new genera that were previously unrecorded for this area.

Yucca House National Monument (YUHO)

1. Mammal, reptile, and invertebrate map; 1990 Sep. 1 sheet; 8.5 inches x 14 inches.

Abstract: Topographic map with hand drawn color legend of reptiles found. Color key to kinds of habitat .

2. Quinn, Hugh. Crotalus viridis. 1984 Dec 27 5 p.

Abstract: Author collected six rattlesnakes at Yucca House on April 17, 1984. The snakes were denning inside a ruin.

3. Quinn, Hugh. Subspecies of Crotalus viridus in Mesa Verde National Park, Yucca House National Monument and Hovenweep National Monument. 1984 Apr 17-1984 Apr 19 1 page.

Abstract: Description of project to identify snakes of subspecies CROTALUS VIRIDUS (rattlesnakes) located at Mesa Verde, Hovenweep and Yucca House. Large population found at Yucca House. No dens located at Hovenweep. Study not conducted at Mesa Verde.

4. Richert, Roland S. and Brandegee, T. S. Fauna and flora of Hovenweep and Yucca House National Monuments and the flora of southwestern Colorado. 1941 Jan 6 & 5 p.

Abstract: "Fauna and Flora" lists reptile species by common & scientific names and relative frequency.

12.3Appendix C: Methods for other Herpetofaunal Species of Special Concern

Many reptile and amphibian species warrant additional research in the SCP park units as species of special concern. These herpetofauna are rare or secretive, and/or have locally restricted or disjunct populations, or are suspected to occur in parks at the extreme edges of their range (Degenhardt et al. 1996, Stebbins 1985, Fowlie 1965). These species were not listed in the main proposal, and we are not seeking funding for them at this time, due to the large amount of effort and funding likely needed to determine their distribution and abundance prior to monitoring. However, information on the location of critical breeding areas for amphibians and the status of bullfrogs is needed at all parks, and can be accomplished within the scope of research outlined in the main proposal.

Amphibians are important bioindicators due to their dependence on water and to their sensitivity to environmental changes, and there has been recent international attention on the problem of widespread amphibian declines (Dunson et al. 1992, Vertucci and Corn 1996). Several species in the list below are apparently found only in relict grassland populations, and may be affected by grazing, climate change, and other factors resulting in loss of grasslands (Abruzzi 1995, Orodho et al. 1990, Jones 1981, Burkhardt and Tisdale 1976). These include: Couch's Spadefoot, little striped whiptail, milk snake, hognose snake, and massasauga (Williams 1994, 1988, Wright and Lowe 1993). The remaining species have locally restricted or disjunct populations, or are suspected to occur in park units at the extreme edges of their range. These species are: northern leopard frog, Couch's spadefoot, Jemez Mountains salamander, Glen Canyon chuckwalla, little striped whiptail, New Mexico whiptail, desert night lizard, milk snake, racer, ringneck snake, Southwestern black-headed snake, and ground snake (Persons 1999, Persons and Bradley 2000, Persons and Wright 1999 a and b, Degenhardt et al. 1996, Stebbins 1985, Fowlie 1965).

12.3.1 Species and Parks

- Northern leopard frog (*Rana pipiens*): GLCA, GRCA, CACH
- Couch's spadefoot toad (*Scaphiopus couchii*): PEFO
- Jemez Mountains salamander (*Plethodon neomexicanus*): BAND
- Glen Canyon chuckwalla (*Sauromalus obesus multiforaminatus)*: GLCA, RABR
- Desert night lizard- (*Xantusia vigilis*): GRCA, GLCA
- New Mexico whiptail (*Cnemidophorus neomexicanus*): PEFO
- Little striped whiptail (*Cnemidophorus inornatus*): PEFO, WUPA, GRCA, CHCU, PETR, AZRU, ELMA, ELMO, BAND, SAPU
- Hognose snake (*Heterodon nasicus*): AZRU
- Milk snake (*Lampropeltis triangulum)*: PEFO, MEVE, CHCU, AZRU, YUHO, WUPA, ELMA, ELMO
- Ground snake (*Sonora semiannulata*): GLCA, GRCA, WUPA
- Ringneck snake (*Diadophis punctatus*): ELMA, ELMO, NAVA, WACA
- Southwestern black-headed snake (*Tantilla hobartsmithi*): GLCA, GRCA
- Racer (*Coluber constrictor*): BAND, PETR, SAPU
- Massasauga (*Sistrurus catenatus*): PETR, SAPU
- Arizona Black rattlesnake (*Crotalus v. cerberus*): SUCR, WACA

12.3.2 Methods

Northern Leopard frog. See amphibian methods section in the proposal. This species is most likely to be detected in permanent pools or along stream edges. Thus, nocturnal audio strip transects and diurnal visual encounter surveys are the best survey methods to use in our area.

Couch's spadefoot. See amphibian methods above. This species is a season explosive breeder, dependent on monsoon rains. It is likely best detected using road driving combined with audio strip transects once breeding pools are detected from the car, and diurnal visual encounter surveys for egg and immature stages.

Jemez Mountains salamander. This salamander is endemic to the mixed-conifer forests in the Jemez mountains in New Mexico (Ramotnik 1997), and thus is of particular management concern at BAND. Plethodontid salamanders are more terrestrial than frogs and toads. Their habitat is suggested to be "moss-covered rockslides, under bark, and beneath (or within decaying) logs on north- and east- facing slopes of mixed conifer, aspen, and deciduous forests above 7000 ft. elevation" (Stebbins 1986, Ramotnik 1997). These salamanders are most likely to be active during June to September, especially during the summer monsoon rains. These salamanders do not use breeding pools, but lay their eggs in decaying logs or stumps. To determine population distribution and abundance of this species, we suggest laying out wooden coverboards in likely habitat (Fellers and Drost 1994). We recommend 2' x 4'x 3/4" boards be used, as smaller and/or thinner boards may not be large enough to produce the necessary humid microclimate favored by salamanders (after Drost et al. 1998). Boards should be checked by flipping them up in the morning or early evening, or whenever conditions under the boards are the coolest and most humid. Another method that may be successful, especially if mere detection of the species is desired, is TCS surveys targeting suitable microhabitats (e.g., flipping and then replacing downed logs and stumps) (Ramotnik 1997).

Glen Canyon chuckwalla. TCS surveys of rock outcrops and rocky hillsides would seem appropriate for detection of this species. This species may be wary, so we suggest using binocular to scan rocks from afar to detect basking lizards in the morning or late afternoon. When scared, chuckwallas will disappear into cracks and crevices, and inflate their bodies so that they are almost impossible to remove (pers. obs. and Stebbins 1986). We would also suggest carrying a mirror or flashlight to direct light into cracks to locate these lizards. (Use a mirror pointed at the sun and bounce the sunlight reflected into crevices).

Desert night lizard. Methods for this species will depend upon the type of information needed by individual park units. If presence/absence, geographic distribution, or habitat association data are sought, general field surveys, including extensive cover-flipping of dead yuccas and other cover (Zweifel and Lowe 1966) will be used. If more intensive studies of local populations are planned, where information on density, population age class structure, or movement patterns are desired, we will use mark-recapture methods, and capture methods will include both repeated general field searches and one-gallon pitfall traps (Fellers and Drost 1991).

Little striped whiptail and New Mexico whiptail. Whiptails are diurnal, active, widely foraging lizards (Pianka 1986), and visual encounter surveys (Crump and Scott 1994) are effective for surveying them. As with the night lizard (above), if presence/absence, distribution, and/or habitat association data are desired, then general field surveys (usually as time-constrained searches) will be used. If more detailed studies of local populations are planned (as may be desirable for the introduced New Mexico whiptail at Petrified Forest), then mark-recapture studies will be used, and will involve the use of 5-gallon pitfall traps.

Hognose snake. This species prefers open sandy or gravelly grassland, floodplain, or canyon bottom habitats. It is infrequent on roads, especially in early evenings (A. Holycross, pers. comm.). Mr. Holycross recommends field searches in the early morning (sunrise to ca. 10am). In addition, he recommends the use of pitfalls and drift fences in sandy habitats.

Milk snake. Milk snakes are generally rare and/or highly secretive throughout their range in the Colorado Plateau region, and effective methods for capturing large numbers snakes have not been developed. In units wishing data on milk snake distribution, abundance, or habitat association, we will use a combination of methods including general field surveys (especially focusing on cover-flipping during early morning and in early spring), night driving, wire screen funnel traps, and placement of artificial coverboards (e.g., Fellers and Drost 1994). Any studies of milk snakes will be iterative, in that we will learn as we go which methods are most effective in which park units, and at what times of year.

Ground snake. See methods for milk snake. Ground snakes are extremely secretive, and spend most of their lives underground. This species tends to live in open habitats with loose soil for burrowing (Stebbins 1986), so we will target those microhabitats. We would also suggest installation of 5-gallon pitfall grids in parks where detection of this species is especially desirable, as they are difficult to detect using visual searching methods (after Drost et al. 1998).

Ringneck snake. See methods for milk snake. Ringneck snakes tend to live in moist microhabitats (pers. obs. and Stebbins 1986), so we suggest targeting those habitats, especially on warm, overcast, damp days and evenings.

Southwestern black-headed snake. See methods for ground snake. These are some of the hardest-to-detect snakes on the Colorado Plateau. Like the ringneck snake, it seems to prefer moister areas (Stebbins 1986). Intensive pitfall trapping and use of coverboards, and training of all park personnel in the identification of this species (in the event that it shows up in a residential area) is likely required to detect them.

Racer. Racers are active, diurnal snakes, and their presence in parks will be determined through general field survey techniques and, in some instances, wire screen funnel traps (Fitch 1951) placed along likely snake travel routes.

Massasauga. In the west, massasaugas are found in shortgrass prairies, desert grasslands, and even in the shinnery oak shrublands of Mescalero Sands, New Mexico (Degenhardt et al. 1996). The best method for detecting this species will likely be night driving from 15 minutes before sunset to ca. 2-3 hours after sunset (A. Holycross, pers. comm.). Mr. Holycross recommends looking for massasauga in early spring or after the monsoon start. Where road driving is not possible, TCS should be conducted in the early morning (sunrise to ca. 9 or 10 am) or in the late afternoon after rainshowers or just after sunset using strong lights. Funnel traps with drift fences may also be moderately effective (A. Holycross, pers. comm.).

Arizona Black rattlesnake. The most efficient method for detection of this species will be targeted TCS surveys. The surveys should focus on potential hibernacula in rock outcrops, especially those with substantial vertical structure surrounded by rock talus (pers. obs.), during spring egress (generally April- May) and fall ingress (September – October). At these times, this species rattles readily (and is thus easily detectable) while basking at the den openings or nearby under talus (pers. obs.).

12.4Appendix D: The SPENCE/ROMME/FLOYD-HANNA/ROWLANDS (SRFR) Classification. Version 3.0 (May 2000)

12.4.1 Introduction

The hierarchical structure of the SRFR system is presented below. Each letter in the alliance ABCDEFGHIJKL is associated with one of the seven levels in the hierarchy. In actual named vegetation, the letters are replaced by numbers, hence the sequence 1012011.01 represents the *Picea engelmannii-Abies lasiocarpa* alliance in the subalpine zone, evergreen forest and woodland formation, on the Colorado Plateau Province in the Nearctic realm (no association is indicated).

A = Biogeographic Realm (1 for Nearctic realm; not shown in classification)
BC = Floristic Province
D = Climate-Elevation Zone
EF = Plant Formation
G = Physiognomic Class
HI = Alliance (first two numbers to right of decimal)
JKL = Association (3+ numbers to right of decimal)

The major difference between this version and version 2.0 is that I have replaced the term series with the term alliance to bring nomenclature in line with the SNVC. A preliminary classification of the Colorado Plateau to the alliance level is presented below. This listing highlights the many gaps in our knowledge of the vegetation on the Colorado Plateau. In particular, high elevation treeless vegetation and wetlands are poorly understood. A preliminary classification and analysis is also presented for the Sonoran-Mojave Desert region and the southern Rocky Mountain region (based on McLaughlin's analysis of floristic provinces in the western US).

12.4.2 Definitions

BC. Floristic Province

The floristic provinces are taken from the analysis of S.P. McLaughlin (J. Biogeography 19: 21-32, 1992).

D. Climate-Elevation Zone

Two aspects of climate need to be considered, regional climate and orographic effects. For regional climate, there are two; subtropical-arid and arid-temperate with cold winters. Although there are latitudinal and longitudinal differences in climate on the Colorado Plateau at similar elevations, orographic effects predominate. The traditional division into boreal-arctic, cold and warm temperate, and subtropical zones is largely controlled by elevation on the Colorado Plateau and in the southwestern United States in general. We have re-drawn the climate zones as elevationally controlled zones, based largely on traditional zonation schemes. Climate zonation remains difficult to use because it can vary locally depending on aspect and topography. As climate data are scarce for much of the Colorado Plateau, no attempt is made here to provide climatic definitions and characteristics for each zone. Some zonal boundaries remain poorly understood (eg., the montane-subalpine boundary). Also, riparian vegetation, as it consists of linear strips cutting across zones, will be more difficult to place into zones than most other kinds of vegetation. Future work addressing these problems, and also in providing a climatic characterization for each zone, is needed.

We recognize that vegetation rarely occurs as discrete elevational bands on the Colorado Plateau. An alternative system could be envisioned in which landscape elements (based on topography, elevation, soils, etc.) are the building blocks of a vegetation classification. Such a system, however, would be far more difficult to use because of its greatly increased complexity. Climate-elevation zones, although less realistic, provide a necessary tradeoff between accuracy of vegetation classification and practicality.

EF. Formation

Forest and woodland. Vegetation dominated by trees (usually or potentially >10 m in height). Forests have closed (interlocking or touching) canopies whereas woodlands have open canopies.

Thornscrub. Tropical-subtropical arid land formation dominated by a mix of microphyllous trees and shrubs, and tall succulents, often spiny or thorny (eg., as in Sonoran desert).

Savanna. Tropical-subtropical formation of grasses with an open canopy of widely spaced trees, dominated by seasonal grass layer.

Shrubland. Vegetation dominated by shrubs, >0.5m in height and mostly <5 m in height, usually multi-stemmed, open (shrubland or scrub) or densely interlocked (thickets). This is traditionally called scrub in many parts of the world.

Dwarf (mat) shrubland. Vegetation dominated by woody, single, or multi-stemmed dwarf or mat shrubs that are generally <0.5m in height.

Grassland. Vegetation dominated by perennial or annual species of grasses.

Marshland. Vegetation dominated by herbaceous obligate emergent wetland species of sedges, rushes, and cattails.

Forbland. Vegetation dominated by herbaceous perennial and annual species of broad leaved dicots, ferns, or non-graminoid monocots (eg., lilies, irises).

Aquatic. Vegetation dominated by herbaceous species that are supported by water, and are either rooted with their structures underwater or floating on the surface, or plants free-floating on the surface.

Cryptogamic. Vegetation dominated by cryptogams, either lichens or bryophytes (includes Sphagnum bogs).

Barren/Nival. Areas essentially bare of vegetation. These can include salt barrens, shale barrens, slickrock, snow or ice. Plants can be present, but occur only as scattered individuals with low cover. In some cases these areas can be named after specific plant species that occur on them. Nival (Permanent snow and ice with some exposed rock, dominated by cryptogams, with vascular plants rare) probably does not occur on the Colorado Plateau, except perhaps in the La Sal Mountains.

G. Physiognomic Class (tentative-more work is needed in some classes)

The dominant species in the vegetation is used to define the class. Mixed classes are possible where no clear dominance occurs by a single species. Woody taxa are classified by leaf duration, including evergreen, cold-deciduous, and drought-deciduous. Grasses and related life forms are classified by height (short<1.0m or tall>1.0m) and growth (sod (rhizomatous, mat/turf) or bunch). Herbaceous forbs are classified by height (short<1.0m or tall>1.0m) and growth (cushion/mat/rosette, erect-stemmed). Marshlands are classified by height as in grasses. Aquatic vegetation is classified as either rooted or free-floating.

HI. Alliance

The alliance is a widely used term throughout the western United States, as used by the U.S. Forest Service in their extensive vegetation classifications. It is defined and named by the dominant species or codominants if more than one occur, in a community. Currently, no set of rules has been formulated for defining a alliance. We incorporated published alliance from a wide variety of sources into our classification. Alliance comprise actual vegetation on a site rather than potential vegetation.

JKL. Association

Associations have traditionally been difficult to define, and we do not attempt to provide a definition here. There is, however, a consistent method available of naming them (eg., the U.S. Forest Service). The name is based on the dominants in all recognizable important strata. For example, under ponderosa pine alliance are the following associations (community-habitat types sensu U.S. Forest Service): Pinus ponderosa/Muhlenbergia virescens, P.p./Festuca arizonica, P.p./Arctostaphylos pungens, etc. Although the emphasis on classifying Colorado Plateau vegetation is not on the association, this method of recognizing and naming associations is probably the best system to use in order to prevent confusion with other work and to be consistent with classifications of the U.S. Forest Service.

01. COLORADO PLATEAU PROVINCE

11 Alpine zone (>3440 m)

1101 Grassland formation
- *1101.01 Carex elynoides series*
- *1101.02 Festuca ovina series*
- *1101.03*

1102 Forbland formation
- *1102.01 Erigeron vagus series*
- *1102.02 Acomastylis rossii series*
- *1102.03*

1103 Low shrubland formation
- *1103.01*

1104 Marshland formation
- *1104.01*

1105 Aquatic formation
- *1105.01*

1106 Barren formation
- *1106.01*

12 Subalpine zone (2750-3600 m)

1201 Forest and woodland formation
- *1201.01 Picea engelmannii-Abies bifolia series*
- *1201.02 Picea engelmannii series*
- *1201.03 Abies bifolia series*
- *1201.04 Populus tremuloides series*
- *1201.05 Pinus longaeva series*
- *1201.06*

1202 Tall shrubland formation
- *1202.01*

1203 Low shrubland formation
- *1203.01 Juniperus communis series*
- *1203.02 Ribes montigenum series*
- *1203.03 Potentilla fruticosa series*
- *1204.04 Salix wolfii series*
- *1203.05*

1204 Grassland formation
- *1204.01 Festuca ovina* series
- *1204.02 Festuca thurberi* series
- *1204.03*

1205 Marshland formation
- *1205.01*

1206 Forbland formation
- *1206.01*

1207 Aquatic formation
- *1207.01*

1208 Barren formation
- *1208.01*

13 Montane zone (1900-3100 m)

1301 Forest and woodland formation
- *1301.01 Pseudotsuga menziesii series*
- *1301.02 Abies concolor series*
- *1301.03 Pinus ponderosa series*
- *1301.04 Pinus flexilis series*
- *1301.05 Populus tremuloides series*
- *1301.06 Juniperus scopulorum series*
- *1301.07 Picea pungens series*
- *1301.08*

1302 Tall shrubland formation
- *1302.01 Cercocarpus ledifolius series*
- *1302.02 Quercus gambelii series*
- *1302.03 Amelanchier utahensis series*
- *1302.04 Robinia neomexicana series*
- *1302.05 Chrysothamnus nauseosus series*
- *1302.06 Betula occidentalis series*
- *1302.07 Alnus tenuifolia series*
- *1302.08 Cornus stolonifera series*
- *1302.69 Salix boothii series*
- *1302.10 Salix bebbiana series*
- *1302.11*

1303 Low shrubland formation
1303.01 Artemisia nova series
1303.02 Purshia tridentata series
1303.03 Arctostaphylos patula series
1303.04

1304 Grassland formation
1304.01 Poa fendleriana series
1304.02

1305 Marshland formation
1305.01 Eleocharis palustris series
1305.02

1306 Forbland formation
1306.01 Pteridium aquilinum series
1306.02 Eriogonum panguicense series
1306.03

1307 Aquatic formation
1307.01

1308 Barren formation
1308.01

14 Submontane/cold temperate lowland zone (900-2200 m)

1401 Forest and woodland formation
1401.01 Pinus edulis series
1401.02 Juniperus osteosperma series
1401.03 Juniperus monosperma series
1401.04 Populus angustifolia series
1401.05 Populus fremontii series
1401.06 Salix goodingii series
1401.07 Acer negundo series
1401.08 Elaeagnus angustifolia series
1401.09 Ostrya knowltonii series
1401.10

1402 Tall shrubland formation
1402.01 Artemisia tridentata series
1402.02 Quercus gambelii series
1402.03 Sarcobatus vermiculatus series
1402.04 Tamarix ramosissima series
1402.05 Salix exigua series
1402.06 Amelanchier utahensis series
1402.07

1403 Low shrubland formation
1403.01 Coleogyne ramosissima series
1403.02 Artemisia spinescens series
1403.03 Artemisia pygmaea series
1403.04 Artemisia filifolia series
1403.05 Eurotia lanata series
1403.06 Atriplex confertifolia series
1403.07 Atriplex canescens series
1403.08 Atriplex corrugata series
1403.09 Atriplex gardneri series
1403.10 Ephedra viridis series
1403.11 Grayia brandegei series
1403.12 Poliomintha incana series
1403.13 Gutierrezia sarothrae series
1403.14 Vanclevea stylosa series
1403.15 Eriogonum corymbosum series
1403.16 Fallugia paradoxa series
1403.17 Quercus harvardii / undulata series
1403.18 Parryella filifolia series
1403.19 Toxicodendron rydbergii series
140.190

1404 Grassland formation
1404.01 Hilaria jamesii-Aristida purpurea series
1404.02 Stipa hymenoides series
1404.03 Stipa comata series
1404.04 Hilaria jamesii series
1404.05 Bouteloua gracilis series
1404.06 Sporobolus cryptandrus-S. contractus series
1404.07 Sporobolus airoides series
1404.08 Bromus tectorum series
1404.09 Distichlis spicata series
1404.10 Elymus salinus series
1404.11 Calamovilfa gigantea series
1404.12 Phragmites australis series
1404.13

1405 Marshland formation
1405.01 Typha latifolia series
1405.02 Typha domingensis series
1405.03 Scirpus pungens series
1405.04 Scirpus validus series
1405.05 Scirpus acutus series
1405.06 Juncus arcticus series
1405.07 Eleocharis palustris series
1405.08 Cyperus erythrorhizos series
1405.09 Carex nebrascensis series
1405.10

1406 Forbland formation
1406.01 Adiantum capillus-veneris series
1406.02 Cleomella palmeriana series
1406.03 Eriogonum flexum series
1406.04 Eriogonum. inflatum series
1406.05 Salsola australis series
1406.06 Melilotus officinalis series
1406.07 Solidago occidentalis series
1406.08 Oxytenia acerosa series
1406.09

1407 Aquatic formation
1407.01 Zanichellia palustris series
1407.02

1408 Barren formation
1408.01 Cercocarpus intricatus series
1408.02 Xylorhiza tortifolia series
1408.03

02. SONORAN DESERT PROVINCE

(preliminary)

Although I have recognized this province based on the analysis of McLaughlin, there may be good reasons to break out the Mojave and Sonoran Deserts into separate provinces from a vegetation classification approach. Levels below the climate zones would be the same as those for the Colorado Plateau, with the addition of the Thornscrub Formation. Physiognomic classes would include relatively few winter-cold deciduous classes below the montane zone.

21 Alpine Zone (>3600 m)

22 Subalpine Zone (>3000 m; characteristic species include Pinus longeava and P. flexilis)

23 Montane Zone (2000-3000 m; characteristic species include Abies concolor, Pinus monophylla, and Artemisia tridentata)

24 Cold-temperate Zone (1300-2100 m; characteristic species include Coleogyne ramosissima, Yucca brevifolia, Canotia holocantha, and Artemisia tridentata)

25 Warm-temperate Zone (300-1400 m, Mojavean; Larrea tridentata dominates this zone)

26 Subtropical Zone (<1000 m, Sonoran, Colorado Desert; a variety of hot desert shrubs and succulents characterize this zone)

03. SOUTHERN ROCKY MOUNTAIN PROVINCE

(preliminary)

I have recognized this province based on the analysis of McLaughlin. There is a long tradition of gradient analysis research in Colorado that was consulted to develop the preliminary climate-elevation zones based on a series of characteristic species.

31 Alpine Zone (>3300 m)

32 Subalpine Zone (2600-3500 m; *Abies bifolia-Picea engelmannii*)

33 Montane Zone (2000-3000 m; characteristic species include *Abies concolor*, *Pinus ponderosa*, and *Pseudotsuga menziesii*)

34 Cold-temperate Zone (<2100 m; *Pinus edulis*, *Juniperus osteosperma, Artemisia tridentata*, various grasslands).

12.5 Appendix E: Example CPVAC Field Data Form for Vegetation

[Scanned form is inserted here in printed copy]

12.6 Appendix F: Unfunded projects (see also Appendix C)

Project Statement #1, Mammals

Project title: Inventories for Selected Potential Species of Concern on the Southern Colorado Plateau.

Problem Statement: In the Southern Colorado Plateau network there are a variety of species that are of potential concern. Reasons for this concern stem from: 1) lack of knowledge about status or population levels of these species; 2) perceptions that these groups are declining even though definitive evidence for the Colorado Plateau is lacking; 3) the fact that individual parks have expressed concern about these species on their lands; or 4) they are listed on various state lists of species of concern. In some cases, some of these species and concerns are incorporated into the full or partial baseline inventories. However, most work on the species or groups included in this statement will require funding beyond that specified in this proposal. Many of these species are endemic to the Colorado Plateau, at least at the subspecific level, and thus they represent considerable portions of the endemic mammalian diversity of the Colorado Plateau (Hall, 1981). Species included are: shrews of the genera *Sorex and Notiosorex* which are widely underrepresented in faunal surveys; selected lagomorphs (*Sylvilagus nuttallii, Lepus americanus, L. townsendii*) which have been reported as extirpated on some parks; several endemic or peripheral ground squirrels (e.g., *Eutamias rufus/hopiensis, Ammospermophilus leucurus ssp., Spermophilus variegatus utah, S. spilosoma cryptospilotus*), prairie dogs (*Cynomys*), and three species of tree squirrels (*Sciurus aberti, Tamiasciurus hudsonicus, Glaucomys sabrinus*); and several poorly known heteromyids with endemic subspecies on the plateau (e.g., *Perognathus fasciatus, P. flavescens, P. flavus, P. parvus, P. longimembris, P. formosus, Chaetodipus intermedius, Dipodomys ordii, D. microps, and D. merriami*).

Objectives:

- Acquire all available historical data on status and occurrence of these species, including copies of theses, dissertations, publications, reports, museum records of voucher specimens, and incorporate these data into a centralized database (Excel or Access);
- Assess occurrence for these species at each park, retaining vouchers as necessary or appropriate;
- Conduct field studies at likely sites of occurrence of these species, primarily at historic sites, as needed, and intuitive sampling of areas deemed to contain these species;
- Evaluate sites where these species are found for their potential for long-term monitoring;
- Provide a final report detailing the investigations at each park, accompanied by distribution maps (in ARCINFO format) of species occurrence at the parks, management recommendations as appropriate, and comments on status of sensitive species.

Study design and methods:

- Objective 1: The PI and staff will review available information at each park, request lists of voucher specimens from appropriate museums, review a master list of potential species at each park, and enter these data into a master file for each park.
- Objective 2: Species will be documented through field inventories; photographs of animals, tracks, or scat; reliable reports of species observed by knowledgeable personnel; and species reported by other agencies (e.g., state fish and game departments).
- Objective 3: Depending upon the size of the park, availability of data upon which park area can be stratified, and possibility of conducting mammal inventories at some of the same sites used by other vertebrate studies, conduct sampling in areas believed to represent appropriate habitat for these species.

- Objective 4: All sites will be evaluated during field studies and subsequent analyses for their potential to serve as long-term monitoring sites because of their uniqueness in terms of species composition, endemicity, or presence of sensitive species.
- Objective 5: The final report, one per park, will be produced in a mutually-agreed to format with all information (species captures/site, voucher specimens, georeferenced localities, distribution maps, etc.) attached as appendices to the final report.

Partnerships: Suitable partners for these surveys should be sought among faculty and graduate students at universities, federal and state agencies (e.g., BLM, FWS, state game agencies), and non-governmental organizations (e.g., TNC), who can serve as partners and contribute funding and personnel.

Schedule: To be determined depending on species and funding available.

Products: Presence and absence data in suitable databases, specimen vouchers as appropriate, and final reports documenting areas searched, level of effort, and results.

Project Statement #1, Vascular plants

Project Title: Review of Herbarium Specimens for Park Inventories, National Park and Regional Herbaria Searches

Problem Statement: The National Park Service has initiated an effort to catalog the presence of all vascular plant taxa occurring within parks in the national National Park Species (NPSpecies) database. Voucher specimens residing in a variety of institutional herbaria represent a significant information resource on the occurrence and distribution of plant species within individual National Parks. Specimen information from these herbaria is not readily accessible or useable for a variety of reasons including misidentification of specimens, uncertain location information, outdated nomenclature and inaccessibility of data.

Herbaria are located at individual National Parks as well as regional and national universities and museums. Ten of the 19 NCPN parks have herbaria (Table A1, below). Although some individual national parks maintain an automated database (ANCS+) for biological and cultural collections, this data is not always complete. There is a need to update this information. The herbarium at CHCU includes only unmounted specimens still in newspaper.

Table A1. Number of Specimens in National Park Herbaria within the Southern Colorado Plateau Network.

AZRU		NAVA	100
BAND	2200	PEFO	700
CACH		PETR	134
CHCU	200	RABR	see GLCA
ELMA		SAPU	
ELMO		SUCR	See WUPA
GLCA	1300	WACA	471
GRCA	8000	WUPA	626
HUTR	No herbarium	YUHO	See MEVE
MEVE	2780		

Due to restrictive NPS collections management polices many regional institutions (e.g. universities) have declined to actively curate collections from the parks. As a result communication between regional (and national) herbaria and national parks within the network has been poor. We suspect that collections at these regional institutions contain many plant specimens from network parks and we propose to conduct electronic and manual herbarium searches at these institutions. Searches of regional collections would be coordinated and cost-shared with adjacent networks such as the Northern Colorado Plateau Network.

We propose to do a variety of herbaria searches to obtain voucher information, as well as verifying identifications in collections held by individual parks in the network. This information will be used to update ANCS+ and NPSpecies databases. In addition, location data will be added to network inventory databases used to map species locations.

Objectives:

1. Conduct an expert review and annotation of all National Park herbaria within the SCPN.

2. Complete an electronic data search of important regional and national herbaria for specimens occurring within SCPN parks.

3. Conduct selected manual herbaria searches to complete gaps in knowledge.

Methods and approach: To meet objective 1 we plan on contracting expert botanical expertise to conduct on-site studies of material in herbarium collections of xx parks, in order to verify identifications. We anticipate a National Park Service employee working side by side with the expert(s) recording annotation information as the collections are reviewed. To ensure that these corrections are incorporated into the ANCS+ database, we will work directly from a print-out of current ANCS+ plant data. Corrections will be manually entered into ANCS+ and NPSpecies databases. We intend to initiate a portion of the herbarium review work in the first year of this project.

Regional and national herbaria are a potential significant source of plant voucher information for the network. Among these larger herbaria are: Brigham Young University (BRY); University of Utah (Garrett); Northern Arizona University (Deaver); University of Wyoming (Rocky Mountain); San Juan College; Utah State University (Intermountain); University of Colorado (Boulder); University of New Mexico; Southern Utah State University; Mesa College; and Ft. Lewis College. National herbaria include California Academy, Missouri Botanic Gardens, and New York Botanic Gardens.

For objective 2 we need to identify which institutional herbaria have specimen data in electronic formats. In year one we plan on initiating some level of data acquisition from these institutions. We are uncertain of the costs associated with obtaining this electronic data. We plan on coordinating and cost-sharing this work with the Northern Colorado Plateau Network vegetation group.

Objective 3 will require site visits to regional herbaria to manually obtain voucher specimen information where electronic data is not available, or there is a need to view the specimens directly. This work would be conducted by trained botanical NPS staff or expert botanical contractors.

Partnerships: Portions of this project targeting acquisition of voucher data from regional and national institutions will be conducted jointly with the Northern Colorado Plateau Network vegetation group. It is possible that other adjacent networks may be interested in a combined effort. Our intention is to cost-share this work where possible.

Products: This project will generate updated presence/absence lists and distribution maps for plant species within Southern Colorado Plateau parks. The identification of all park herbarium collections will be verified and annotated accordingly. These corrections and updates will be incorporated into ANCS+ and NPSpecies databases.

Implementation: This project will be coordinated by the SCPN Inventory and Monitoring Program Manager. The work will be conducted through a combination of contract and in-house work. We will seek the best expert botanical assistance available for the verification of park plant collections.

Funding: At this time we do not have enough funding to do the work associated with this project. We plan on seeking additional funding through other NPS regional and national competitions. Any additional funding will be used to complete as many of the herbaria reviews as searches as possible.

Budget Item	FY 2001	FY 2002	FY 2003	FY 2004
Salaries	7,000	8000		
Travel	2,700	2000		
Supplies	300			
Contributed/Matching Funds				
TOTAL	10,000	10,000		

Project Statement #2, Vascular plants

Project title: Documentation of exotic species in parks in the Southern Colorado Plateau and prioritizing management needs

Problem Statement – The invasion of non-native species, including plants, has become of world-wide concern. Exotic species have been found to effect ecosystem processes and in some cases to compete with and sometimes exclude native species. (Mack 1989, Vitousek 1992, Howe and Knopf 1991, Christian and Wilson 1999). In some cases, invasion may contribute to the overall biodiversity of an area by adding species to those already present, although with unknown or poorly understood effects on ecosystem function (Pimm 1991, Parker et al. 1999).

In North America, many national parks and monuments have been invaded by exotic plant species to some degree (Hiebert 1997). Recently, efforts to document the presence of exotic plant species over large areas of United States have been undertaken. These include the Southwest Exotic Plants Management Project (SWEMP) and the ongoing development by the USGS Colorado Plateau Field Station of a regional database of alien plant species occurrence and abundance. An integrated effort to document the presence of exotic plant species in national parks of the northern and southern Colorado Plateau will provide information for both regional and national perspectives, as well as park-specific management efforts.

Objectives: The first objective is to document and compile information on non-native plant species distribution and abundance in parks of the southern Colorado Plateau cluster. This will be a coordinated effort with the ongoing collection, evaluation, and compilation of data on plants and animals for inventory purposes. This will also be done in cooperation with the northern Colorado Plateau inventory, in order to create data tables with comparable structure and data.

The second objective is to evaluate the known data on exotic species, and, after consultation with park resource managers, to determine which species are of most concern, and what areas are most likely being

impacted. Distributions will be mapped, and sampling to determine abundance will be undertaken. The southern and northern Colorado Plateau clusters will work together to develop priorities and methods appropriate to the selected species and sites.

Park managers will have the information necessary to begin monitoring and managing populations of exotic plant species, using tools such as alien plant ranking system (APRS), developed by Hiebert and Stubbendieck (1993). This effort will also be coordinated with other projects currently being developed in the region, for regional data bases (USGS Colorado Plateau Field Station) and integrated web sites where APRS and SWEMP will be available as part of a management decision support system.

Methods: Information will be collected in conjunction with the ongoing inventory. Data already in tables will be screened for exotic species, and new information will be included. Data collected during basic inventories at the parks will be included when available. Consultation with resource managers and the application of ranking techniques found in Hiebert and Stubbendieck (1993) will result in priorities for further work on particular species and at particular parks.

The next phase will include mapping of the distribution of target species and sampling to make estimates of abundance. Mapping will be done with GPS, and sampling methods will be selected that will be appropriate for monitoring. The southern Colorado Plateau cluster will seek to cooperate with the northern cluster at all stages, including the development of data tables, priorities, and sampling methods.

Schedule: The data collection and review can begin immediately, as part of the ongoing inventory. Field work will be dependent on the target species and their phenology. The Inventory and Monitoring Coordinator will provide guidance on timing of field work and methods to be used.

Funding: Requirements for field work, coordination, data base management, integration with other projects, $110,000.

Review of Herbarium Specimens for Park Inventories

Priority 2 2001-2002

Item	Year 1	Year 2
Personnel Costs		
Project Leader		
Botanist @ $800 per week for 6 weeks	$4,800	$4,800
Benefits @ 9.31%	$447	$447
Data Manager		
Data Manager @ $800 per week for 2 weeks	$1,600	$1,600
Fringe Benefits @ 9.31%	$149	$149
Personnel Costs total	**$6,996**	**$6,996**
Travel and Per diem		
Vehicle and Mileage costs		
1 vehicle @ $175 per week x 5 weeks	$875	$875
Travel @ $0.12/mi x 2400 miles	$288	$288
Per diem		
Per diem @ $20/day/person x 45 days	$900	$900
Travel costs total	**$2,063**	**$2,063**
Miscellaneous Costs		
Film, xeroxing, herbarium supplies, etc.	$500	$500
Miscellaneous Costs Total	**$500**	**$500**
Total Direct Costs	**$9,559**	**$9,559**
Total Indirect Costs (CESU @ 15% of direct costs)	**$1,434**	**$1,434**
Total Costs	**$10,993**	**$10,993**

12.7Appendix G: List of Contributors with Resumes

Dr. Michael Bogan, **Mammals**

Dr. Anne Cully, **Plants**

Charles Drost, **Amphibians, Reptiles and Mammals**

Dr. Ron Hiebert, **Project Management and Coordination**

Matthew Johnson, **Birds**

Dr. David Mattson, **General Sampling and Species Estimation**

Erika Nowak, **Amphibians and Reptiles**

Trevor Persons, **Amphibians and Reptiles**

Dr. John Spence, **Plants, Physical and Biological Setting**

Dr. Kathryn Thomas, **Plants, Vegetation mapping**

Michael A. Bogan

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PRESENT POSITIONS

Project Leader, Aridland Field Station, US Geological Survey, Albuquerque

Research Professor in Biology, University of New Mexico, Albuquerque

Curator of Vertebrates, Museum of Southwestern Biology, Albuquerque

EDUCATION

Ph.D. in Biology, 1973; University of New Mexico (Advisor: Dr. James S. Findley)

M.S. in Zoology, 1966; Fort Hays State University (Advisor: Dr. Eugene D. Fleharty)

B.S. in Biology, 1964; Baker University, Baldwin City, KS

RESEARCH ACTIVITIES

Biodiversity, Conservation, Systematics, Biogeography, Land Management, Biological Surveys, Chiroptera, Rodentia, Endangered Species

RECENT PUBLICATIONS

Alvarez-Castañeda, S.T., and M.A.53 Bogan. 1998. *Myotis peninsularis*. American Society of Mammalogists, Mammalian Species, 573:1-2.

Alvarez-Castañeda, S.T., and M.A. Bogan. 1997. *Myotis milleri*. American Society of Mammalogists, Mammalian Species, 561:1-3.

Alvarez-Castañeda, S. T., F. A. Cervantes, P. Cortes-Calva, and M. A. Bogan. submitted. Observations on mammals from Isla Espiritu Santo, Baja California Sur. 16pp. The Southwestern Naturalist.

Bogan, MA. 1999. Family Vespertilionidae. *In* The mammals of northwestern Mexico (S.T. Alvarez-Castañeda and J.L. Patton, eds.)

Bogan, M.A. 1999. California myotis, *Myotis californicus*. Pp. 85-86 *in* Complete book of North American mammals, D.E. Wilson and S. Ruff (eds.). Smithsonian Institution Press, Washington, DC.

Bogan, M.A. 1999. Western small-footed myotis, *Myotis ciliolabrum*. Pp. 87-88 *in* Complete book of North American mammals, D.E. Wilson and S. Ruff (eds.). Smithsonian Institution Press, Washington, DC.

Bogan, M.A. 1999. Long-eared myotis, *Myotis evotis*. Pp. 88-90 *in* Complete book of North American mammals, D.E. Wilson and S. Ruff (eds.). Smithsonian Institution Press, Washington, DC.

Bogan, M.A. 1999. Gray myotis, *Myotis griscesens*. Pp. 90-92 *in* Complete book of North American mammals, D.E. Wilson and S. Ruff (eds.). Smithsonian Institution Press, Washington, DC.

Bogan, M.A. 1999. Eastern small-footed myotis, *Myotis leibii*. Pp. 93-94 *in* Complete book of North American mammals, D.E. Wilson and S. Ruff (eds.). Smithsonian Institution Press, Washington, DC.

Bogan, M.A. 1997. Bats happen-ecologically:(Review of) Ecology, evolution and behavior of bats by P.A. Racey and S.M. Swift (eds.). Ecology, 78(4):1293-1294.

Bogan, M.A. 1997. On the status of *Neotoma varia* from Isla Dátil, Sonora. Pp. 81-87 *in* Life among the muses: Papers in honor of James S. Findley. T.L. Yates, W.L. Gannon and D.E. Wilson, (eds.). Special Publication, Museum of Southwestern Biology, No. 3. 308 pp.

Bogan, M.A. 1997. Historical changes in the landscape and vertebrate diversity of north central Nebraska. Pp. 105-130 *in* Ecology and conservation of Great Plains vertebrates. F.L. Knopf and F. B. Samson (eds.). Springer-Verlag, New York, 320 pp.

Bogan, M. A., and P. M. Cryan. 2000. The bats of Wyoming. Pp. 71-94 in Reflections of a Naturalist: Papers honoring Professor Eugene D. Fleharty, J. R. Choate, ed. Fort Hays Studies, Spec. Issue 1.

Bogan, M.A., and R.B. Finley, Jr. 1996. (Review of) Mammals of Colorado by J. Fitzgerald, C. Meaney, and D. M. Armstrong. Journal of Mammalogy, 77:901-904.

Bogan, M.A. and C.A. Ramotnik. 1999. Mammalian species diversity of the Grand Staircase-Escalante National Monument. Pp. 153-159 *in* Learning from the land: Grand Staircase-Escalante National Monument Science Symposium Proceedings, L.M. Hill (ed.). Bureau of Land Management, BLM/UT/G1-98/006+1220.

Bogan, M.A., J.G. Osborne, and J.A. Clark. 1996 (1997). Observations of bats at Badlands National Park, South Dakota. The Prairie Naturalist, 28(3):115-123.

Bogan, M.A., T.J. O Shea, and L. Ellison. 1996. Diversity and conservation of bats in North America. Endangered Species Update, 13(4 and 5):1-2 & 14.

Bogan, M.A., C.D. Allen, E.H. Muldavin, S.P. Platania, J.N. Stuart, G.H. Farley, P. Mehlhop, and J. Belnap. 1999. The Southwest. Pp. 543-592 *in* Status and trends of natural resources in the United States. M. J. Mac, P.A. Opler, and P.D. Doran (eds.). U.S. Department of Interior, U.S. Geological Survey, Washington, DC.

Bogan, M.A., T.J. O Shea, P.M. Cryan, A.M. Ditto, W.H. Shaedla, E.W. Valdez, K.T. Castle, and L. Ellison. 1998. A study of bat populations at Los Alamos National Laboratory and Bandelier National Monument, Jemez Mountains, New Mexico. FY95-97 report to Los Alamos National Laboratory and Bandelier National Monument. Los Alamos National Laboratory, LA-UR-98-2418.

Cryan, P. M., M. A. Bogan, and J. S. Altenbach. 2000. The affect of elevation on the distribution of female bats in the Black Hills, South Dakota. Journal of Mammalogy. In press.

Cryan, P. M., M. A. Bogan, and G. M. Yanega. submitted. Roosting habits of four bat species in the Black Hills of South Dakota. Journal of Mammalogy.

Finley, R.B., Jr., and M.A. Bogan. 1995. New records of terrestrial mammals in northwestern Colorado. Proceedings, Denver Museum of Natural History, Series 3, 10:1-6.

Kennedy, M. L., P. K. Kennedy, M. A. Bogan, and J. L Waits. submitted. Geographic variation in the black bear (*Ursus americanus*) in the eastern United States and Canada. 36pp. Southwestern Naturalist.

Kennedy, M. L., P. K. Kennedy, M. A. Bogan, and J. L. Waits. submitted. Taxonomic assessment of the subspecific taxonomy of the black bear (*Ursus americanus*) in the Eastern United States. Proceedings Biological Society of Washington.

Mollhagen, T.R., and M.A. Bogan. 1997. Bats of the Henry Mountains region of southeastern Utah. Occasional Papers, Museum of Texas Tech University, Number 170:1-13.

Perry, T.W., P.M. Cryan, S.R. Davenport, and M.A. Bogan. 1997. New locality for *Euderma maculatum* (Chiroptera: Vespertilionidae) in New Mexico. The Southwestern Naturalist, 42(1):99-101.

Valdez, E. W., J.R. Choate, M.A. Bogan, and T.L. Yates. 1999. Taxonomic status of *Myotis occultus* (Hollister). Journal of Mammalogy.

Valdez, E.W., J.N. Stuart, and M.A. Bogan. 1999. Additional records of bats from the Middle Rio Grande Valley, New Mexico. The Southwestern Naturalist.

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Flagstaff, Arizona 86011-5765
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EDUCATION

2000	Kansas State University, Manhattan, Kansas Doctor of Philosophy, Biology (Plant Ecology) Ph.D. 2000
1977	University of New Mexico, Albuquerque, New Mexico Master of Science, Biology (Plant Ecology)
1971	University of New Mexico, Albuquerque, New Mexico Bachelor of Arts, Major-Anthropology

EMPLOYMENT

August 2000 to present – **Plant Ecologist**, Colorado Plateau Cooperative Ecosystem Studies Unit, National Park Service

January 1997 to August 2000 **- Graduate Research Assistant**, Division of Biology, Ackert Hall, Kansas State University, Manhattan, Kansas.

December, 1995 to December, 1997 - **Fish and Wildlife Biologist**, U. S. Fish and Wildlife Service, Kansas Ecological Services Field Office, Manhattan, Kansas.

October, 1990 to December, 1995 - **Botanist**, U.S. Fish and Wildlife Service, New Mexico Ecological Services Field Office, Albuquerque, New Mexico.

April, 1985 to September, 1990 - **Botanist (Planner IV**), State Forestry Division, New Mexico Energy, Minerals and Natural Resources Department, Santa Fe, New Mexico.

1979 to 1985 - **Research Associate**, Biology Department, University of New Mexico, Albuquerque, New Mexico.

1977 to 1979 - **Botanical and palynological consultant**.

1975 to 1976 - **Research Assistant**, Biology Department, University of New Mexico, Albuquerque, New Mexico.

SELECTED PUBLICATIONS, PRESENTATIONS, AND REPORTS

Knight, P.J., S. Lucas, and **A.C. Cully**. 1996. An early Pleistocene flora from Central New Mexico. Southwestern Naturalist 41(3):207-217.

Cully, A.C. 1996. Knowlton's cactus (Pediocactus knowltonii) reintroduction. In Restoring diversity: Strategies for reintroduction of endangered plants, pp 403-410. D.A. Falk, C.I. Millar, and M. Olwell, editors. Island Press, Washington, D.C.

Knight, P.J. and **A.C. Cully**. 1991. A new species of Astragalus from southeastern New Mexico. The Southwestern Naturalist 34(4):487-498.

Staehlaker, D., P. Kennedy, **A. Cully**, and B. Kuykendahl. 1989. Breeding bird assemblages at Guadalupe Mountain, Taos County, New Mexico. The Southwestern Naturalist 34(4):487-498.

Cully, A.C. and J.F. Cully, Jr. 1989. Spatial and temporal variation in annual vegetation at Chaco Canyon, New Mexico. Great Basin Naturalist 49(1):113-122.

Cully, A.C. 1979. Some aspects of pollen analysis in Archaeology. The Kiva 44(2-3):95-100.

Presentations:

The effects of size and fragmentation on invasion of tallgrass prairie fragments by non-native plant species. Fifth International Conference on the Ecology of Invasive Alien Plants. La Maddalena, Sardinia, Italy. 1999.

Reintroduction of Pediocactus knowltonii: A case study. Symposium on Restoring Diversity: Is Reintroduction an Option for Endangered Plants? Center for Plant Conservation, Missouri Botanical Garden, St. Louis, Missouri. 1993.

Preliminary results of a long-term monitoring study of Mesa Verde cactus (Sclerocactus mesae-verdae). Southwestern Rare and endangered Plant Conference, Santa Fe, New Mexico. 1992.

Preliminary results from monitoring two populations of Sclerocactus mesae-verdae. Third Annual Conference, Society for Conservation Biology, University of California at Davis. 1988. (With M. Olwell, D. House, P.J. Knight)

Indian ricegrass (Oryzopsis hyemenoides):A potentially useful wild grass species adapted to dunal habitats. Meeting on Management and Utilization of Arid Land Plants, Saltillo, Coahuila, Mexico. U.S.D.A. Rocky Mountain Forest and Range Experiment Station, Secretaria Agricultura y Recursos Hydrologicas, and UNESCO Program on Man and the Biosphere. 1985.

Additional Reports and Publications

Crawford, C.S., **A.C. Cully**, R. Leutheuser, M.S. Sifuentes, L.H. White, J.P. Wilber. 1993. Middle Rio Grande Ecosystem: Bosque Biological Management Plant. Bosque Interagency Team (Army Corps of Engineers, Bureau of Reclamation, Fish and Wildlife Service, University of New Mexico). U.S. Fish and Wildlife Service, Region 2, Albuquerque, New Mexico.

Cully, A.C., P.J. Knight, P. Olwell, and D. House. 1992. Preliminary results of a long-term monitoring study of the Mesa Verde cactus (Sclerocactus mesae-verdae), pp. 108-120. In Proceedings of the southwestern rare and endangered plant conference. R. Sivinski and K. Lightfoot, editors. New Mexico Forestry and Resources Conservation Division. Santa Fe.

Cully, A.C. and P.J. Knight. 1988. Status report on Amsonia fugatei. Report on file, U.S. Fish and Wildlife Service. Albuquerque, New Mexico.

Olwell, M., **A. Cully**, P. Knight, and S. Brack. 1987. Recovery efforts for Pediocactus knowltonii, pp. 519-512. In Conservation and Management of Rare and Endangered Plants. T.S. Elias, editor. California Native Plant Society. Sacramento, California.

Cully, A.C. and P.J. Knight. 1987. Status report on Sibara grisea. Report on file, U.S. Fish and Wildlife Service. Albuquerque, New Mexico.

Cully, A.C. and P.J. Knight. 1987. A handbook of vegetation maps of New Mexico Counties. New Mexico Department of Natural Resources. Santa Fe, New Mexico.

Cully, A.C. 1986. Indian ricegrass (Oryzopsis hymenoides): A potentially useful wild grass adapted to dunal habitats. In Management and utilization of arid land plants: Symposium proceedings. February, 18-22, Saltillo, Mexico. Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Knight, P.J. and **A.C. Cully**. 1986. Status report on Senecio quaerens (Gila groundsel). Report on file, U.S. Fish and Wildlife Service. Albuquerque, New Mexico.

Charles A. Drost

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Colorado Plateau Research Station
Box 5614, Northern Arizona University
Flagstaff, AZ 86011

EDUCATION:

1989 University of California, Davis, 1989
M. A., Zoology:
1979 Auburn University
B. S., Biology:

RESEARCH EXPERIENCE:

Zoologist, National Biological Service / Colorado Plateau Research Station (1993 - present)
Population studies of vertebrate species. Inventory studies in Colorado Plateau Parks. Research on declining amphibian species. Design and management of surveys for rare mammal, reptile and amphibian species.

Zoologist, Cooperative Parks Studies Unit, University of California, Davis, CA (1989 - 1993)
Review of native animal restoration and non-native animal control work in natural reserves. Research on declining amphibian species. Ecology of threatened Santa Rosa Island spotted skunk. Biological diversity in California National Parks.

Biological Consultant, Davis, CA (1989 - 1992)
Design, fieldwork, and reporting for biological studies for private and government agencies, including: 1) surveys of plants, vertebrate animals, and potential environmental impacts of proposed construction on islands in the Sacramento River delta; 2) intensive survey for rare plant species within project area of proposed dam.

Zoologist, Channel Islands National Park, Ventura, CA (1985 - 1989)
Population studies of terrestrial vertebrates and invertebrates on the Channel Islands of southern California, including: 1) design of survey and population monitoring techniques; 2) field surveys and tests of techniques; 3) development of computer databases and programs for analyzing data; and 4) statistical analysis. Co-authored comprehensive monitoring handbooks for the Park.

Thesis research, Predation and Population Cycles on a Southern California Island (1984 - 1989)
Studied relationship of deer mouse population cycles to weather patterns, predation pressure, and predation on alternative prey species. Designed and carried out censuses of mice and predators, collected food habits and mortality data, and analyzed and synthesized results for professional papers.

Biological Technician, Channel Islands National Park (1981 - 1984)
Research on ecology of endangered island night lizard. Conducted field work, analyzed parts of the resulting data (food habits, predation), collaborated on statistical analysis, and on writing and editing the resulting monograph.

Wildlife Assistant, Carson National Forest, Taos, NM (1980)
Field studies ranging from an alpine plant survey to habitat evaluation for restoration of White-tailed Ptarmigan, to habitat use and population ecology of a herd of Bighorn Sheep. Assumed primary responsibility for habitat evaluation for restoration of White-tailed Ptarmigan. Assisted in wildlife surveys on timber tracts, including bird counts, searches for deer and elk sign, and vegetation description.

PUBLICATIONS:

Drost, C. A., and D. W. Blinn. 1997. Invertebrate Community of Roaring Springs Cave, Grand Canyon National Park, Arizona**. Southwest Naturalist 42:497-500.**

Drost, C. A., and M. K. Sogge. 1996. Preliminary survey of leopard frogs in Glen Canyon National Recreation Area. Proceedings of the Second Biennial Conference on Research on the Colorado Plateau. National Park Service Transactions and Proceeding Series NPS/NRNAU/NRTP-95/11

Drost, Charles A., and Gary M. Fellers. 1996. Collapse of a Regional Frog Fauna in the Yosemite Area of the California Sierra Nevada, USA. Conservation Biology 10(2):414-425

Drost, Charles A., and Elena T. Deshler. 1995. Status of reptiles and amphibians on the Colorado Plateau. Pages 326-328 In: E. T. LaRoe et al. (eds.), Our Living Resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. National Biological Service, Washington, D. C.

Drost, Charles A., and Gary M. Fellers. 1995. Non-native animals on public lands. Pages 440-442 In: E. T. LaRoe et al. (eds.), Our Living Resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. National Biological Service, Washington, D. C.

Fellers, Gary M., and **Charles A. Drost**. 1995. Handbook for Restoring Native Animals. Natural Resources Report NPS/NRPORE/NRR-95/19. U.S. Department of Interior, National Park Service. Natural Resources Publication Office, Denver, CO.

Drost, Charles A., and David B. Lewis. 1995. Xantus' Murrelet (*Synthliboramphus hypoleucus*). In: The birds of North America, A. Poole and F. Gill, eds. The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.

Fellers, Gary M. **Charles A. Drost**, and W. Ronald Heyer. 1994. Handling live amphibians. pp. 275-276 in: Heyer, W. Ronald, et al. (eds.) Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press, Washington, D. C.

Fellers, Gary M. and **Charles A. Drost**. 1994. Sampling with artificial cover. pp. 146-149 in: Heyer, W. Ronald, et al. (eds.) Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press, Washington, D. C.

Drost, Charles A., and Gary M. Fellers. 1994. Decline of Frog Species in the Yosemite Section of the Sierra Nevada. Final report to Yosemite National Park and the Yosemite Association, iii + 54 pp.

Junak, Steve, Ralph Philbrick, and **Charles Drost**. 1993. A revised flora of Santa Barbara Island. pp. 54-112 in: M. Daily (ed.), Santa Barbara Island. Occasional Paper No. 6, Santa Cruz Island Foundation, Santa Barbara, California.

Drost, **Charles A.**, and Thomas J. Stohlgren. 1993. Natural Resource Inventory and Monitoring Bibliography. Technical Report NPS/WRUC/NRTR-93/04. U.S. Department of Interior, National Park Service. Cooperative National Park Studies Unit. University of California, Davis, CA.

Fellers, Gary M. and **Charles A. Drost**. 1993. Disappearance of the Cascades Frog, *Rana cascadae*, at the Southern End of its Range, California, USA. Biological Conservation 65:177-181.

Ronald D. Hiebert

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EDUCATION:

1965-1968 Southwestern State University of Oklahoma: B.S. Biology

1973-1977 University of Kansas: M.S. Botany and Ph.D. Botany

POSITIONS HELD:

1977-1978 Assistant Professor, University of Northern Colorado

1979-1981 Ecologist, National Natural Landmarks Program

1982-1988 Chief Scientist, Indiana Dunes National Lakeshore

1988-1995 Chief Scientist, Midwest Region, National Park Service

1986-1999 Associate Regional Director, Midwest Region, National Park Service

1999-present Research Coordinator and CP-CESU leader, Colorado Plateau, National Park Service

HONORS AND SPECIAL ASSIGNMENTS

1992 Regional Director's Award for Outstanding Leadership in Environmental Resources Management

1993 National Park Service Exotic Task Force

1994-Present Chair, Editorial Board, *Park Science*

1995 Meritorious Service Award, U.S. Department of the Interior

1998 Invited participant in international workshop on invasive species. National Center for Ecological Analysis and Synthesis, Santa Barbara, CA

1998 National Park Service representative to 1st International Workshop on Weed Risk Assessment, Adelaide, S. Australia

SELECTED PUBLICATIONS

Hiebert, R.D. 1977. The population biology of bristlecone pine (*Pinus longaeva*) in the Eastern Great Basin. University of Kansas. (Dissertation)

Hiebert, R.D., and J.L. Hamrick. 1983. Patterns and levels of genetic variation in Great Basin bristlecone pine, *Pinus longaeva. Evolution* 37:302-310.

Hiebert, R.D., and J.L. Hamrick. 1984. An ecological study of bristlecone pine (*Pinus longaeva*) in Utah and eastern Nevada. *Great Basin Naturalist* 44:487-494.

Wilcox, D.A., S.L. Apfelbaum, and **R.D. Hiebert**. 1985. Cattail invasion of sedge meadows following hydrologic disturbance in the Cowles Bog Wetland Complex, Indiana Dunes National Lakeshore. *Wetlands* 4:114-127.

Hiebert, R.D. 1990. An ecological restoration model: application to razed residential sites. *Natural Areas Journal* 10:181-186.

Hiebert, R.D. 1990. Managing alien plants. *Trends* 27:12-16.

Hiebert, R.D. and J. Stubbendieck. 1993. Handbook for Ranking Exotic Plants for Management and Control. USDI, National Park Service Natural Resources Report NPS/NRMWRO/NRR-93/08. 29pp.

Hiebert, R.D. 1996. Prioritizing invasive plants and planning for management. Pp 195-214. In *Assessment and Management of Invasive Plants,* J. Luken and J. Thieret, Ed., Springer, NY.

Hiebert, R.D. (with R. Andracek, T. Cacek, R. Doren, L. Fox, and G. Johnston) 1996. Preserving our national heritage: a strategic plan for managing invasive plants on National Park system lands. USDI, NPS. 16 pp.

Peloquin, R.L. and **R.D. Hiebert**. 1999 The effects of *Robinia psuedoacacia* on the species diversity and composition of black oak savannahs/woodlands. *Natural Areas Journal* 19:121-131.

Simberloff, D., D. Gordon, **R. Hiebert**, M. Lonsdale, and A. Draheim. A global database: key to weighing on-the-ground invasive species impacts. *Natural Areas Journal* (in press).

APRS Implementation Team. 2000. Alien plants ranking system version 5.1. Jamestown, ND. Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/2000/aprs/aprs.htm

MATTHEW J. JOHNSON

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EDUCATION

1994-1997	NORTHERN ARIZONA UNIVERSITY, Flagstaff, Arizona Master of Science in Avian Ecology
1990-1992	WEBER STATE UNIVERSITY, Ogden, Utah Bachelor of Science in Wildlife Biology
1978-1983	WESTERN STATE COLLEGE, Gunnison, Colorado Bachelor of Arts in Applied Education, Minor Business Administration

RESEARCH EXPERIENCE

WILDLIFE BIOLOGIST - Population status and distribution of the avian community at Pipe Spring National Monument, Arizona and Canyonlands National Park, Utah; monitoring land birds (including raptors and owls), setting up and implementing permanent transects. Also responsible for oral presentations at agency and public meetings, and providing park with monthly reports on the progress and status of the study. **COLORADO PLATEAU RESEARCH STATION/NORTHERN ARIZONA UNIVERSITY (CPFS)**. Supervisor: Dr Charles van Riper III, Phone (520) 556-7466 ext. ext. 227. 1998-present

WILDLIFE BIOLOGIST - Plan, coordinate and implement research on breeding ecology, winter distribution and abundance of Southwestern willow flycatchers in Central America, Grand Canyon NP, Canyonlands NP and throughout the Colorado Plateau. Determine presence, reproductive status, habitat occupancy, foraging patterns and breeding biology of this endangered species. **CPFS**. Supervisor: Mark Sogge, Ecologist. 1992-present.

THESIS RESEARCH - Studies on brown-headed cowbird brood parasitism effects on black-throated sparrows in north-central Arizona. Coordinated and conducted research, including: designing protocols; hiring, training, and supervising staff; budget tracking; data evaluation and analysis; and preparing scientific journal articles and agency reports. Also, responsible for preparing and delivering oral presentations at agency meetings, public meetings and scientific conferences. **CPFS**. Supervisor: Dr. Charles van Riper III. 9/94-5/97.

WILDLIFE BIOLOGIST - Develop brown-headed cowbird inventory and monitoring program for Montezuma Castle National Monument, Arizona. Establish sampling sites, collect inventory data, evaluate habitat characteristics, and write monthly and annual reports. Supervised a two-person crew locating and monitoring nests of host species parasitized in riparian zones. **KERN RIVER RESEARCH CENTER, CALIFORNIA**. Supervisor: Murrelet Halterman. 3/95-8/96.

RESEARCH ASSISTANT - Collected baseline information on distribution and abundance of the avian community at Montezuma Castle NM, Arizona. Field monitoring of land birds (including raptors and owls). Also gave oral presentations at agency and public meetings, and prepared monthly reports on the progress and status of the study. **COOPERATIVE PARK STUDIES UNIT/NORTHERN ARIZONA UNIVERSITY**. Supervisor: Mark Sogge. 1/92-8/94.

WILDLIFE BIOLOGIST - Field supervisor for population inventory of Mexican spotted owls in central and southern Utah. Duties included route selection and setup for designated survey areas, organizing a three-person crew to complete each survey, and preparing daily and ten-day reports of all owl sightings and status of surveys completed. Also captured individual owls for radio and band placement, and tracked individuals to determine home range occupancy for a telemetry research project in Zion National Park, Utah. **HIGH DESERT RESEARCH**. Supervisor: David Willey. 5/91-10/91

PUBLICATIONS

Sogge, M.K. and **Johnson, M.J.**, . 1998. A checklist of birds of Montezuma Castle and Well National Monuments and Vicinity. Southwest Parks and Monument Association, Tucson, AZ.

Johnson, M.J. 1997. Cowbird brood parasitism of the Black-throated Sparrow in the Verde Valley of central Arizona. Master's thesis, Flagstaff, Arizona, Northern Arizona University.

Johnson, M.J., and M.K. Sogge. 1995. Cowbird concentrations at livestock corrals in Grand Canyon National Park. Pages 275-284 in C. van Riper III, Editor. Proceedings of the Second Biennial Conference on Research in Colorado Plateau National Parks, 25-28 October 1993. National Park Service Transactions and Proceedings Series NPS/NRNAU//NRTP-95/11.

Johnson, M.J., and M.K. Sogge. 1995. A checklist of birds of Tuzigoot National Monument and Vicinity. Southwest Parks and Monument Association, Tucson, AZ.

Johnson, M.J., L.E. Ellison and M.K. Sogge. 1993. Southwestern Willow Flycatcher declines in Grand Canyon National Park. Park Science 13:12-13.

SELECTED TECHNICAL AND AGENCY REPORTS

Johnson, M.J. 1999. Southwestern Willow Flycatcher and Western Yellow-billed Cuckoo Surveys along the Colorado and Green Rivers in Canyonland National Park. Colorado Plateau Field Station/Northern Arizona University. 33 pp.

Tibbitts, T. and **Johnson, M.J.**, 1999. Southwestern Willow Flycatcher surveys conducted along the Colorado River Corridor in Grand Canyon National Park. Colorado Plateau Field Station/Northern Arizona University. 18 pp.

Johnson, M.J. and C. O'Brien. 1998. Southwestern Willow Flycatcher and Western Yellow-billed Cuckoo Surveys along the San Juan River, Utah (Four Corners Bridge - Mexican Hat and Clay Hills Crossing). Colorado Plateau Field Station/Northern Arizona University. 45 pp.

Johnson, M.J. 1998. Southwestern Willow Flycatcher Surveys in the Manti-La Sal National Forest (Moab and Monticello Districts) Utah. Colorado Plateau Field Station/Northern Arizona University. 19 pp.

Johnson, M.J. and C. van Riper III. 1998. The Black-throated Sparrow at Montezuma Castle National Monument in the Verde Valley of Central Arizona. Colorado Plateau Field Station/Northern Arizona University. Technical Report Series USGSFRESC/COPL/1998. 45 pp.

Sogge, M.K. and **M.J. Johnson.** 1998. Montezuma Castle Avian Inventory 1991-1994. Colorado Plateau Field Station/Northern Arizona University. 202 pp.

Tibbitts, T. and **Johnson, M.J.**, 1998. Southwestern Willow Flycatcher surveys conducted along the Colorado River Corridor in Grand Canyon National Park. Colorado Plateau Field Station/Northern Arizona University. 18 pp.

David J. Mattson

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EDUCATION

1979	University of Idaho B.S. Forest Resource Management
1984	University of Idaho M.S. Forest Ecology
2000	Ph.D. University of Idaho, Wildlife Resource Management

PROFESSIONAL POSITIONS

1999-present	**Research Wildlife Biologist;** U.S.G.S. Colorado Plateau Field Station, Flagstaff
1996-1999	**Research Wildlife Biologist**, U.S.G.S. Forest & Rangeland Ecosystem Science Center, Corvallis, OR Research Wildlife Biologist
1993-1996	**Wildlife Biologist**, National Biological Service, Cooperative Park Studies Unit, University of Idaho, Moscow
1984-1992	**Wildlife Biologist**, National Park Service, Interagency Grizzly Bear Study Team, Bozeman, MT

PROFESSIONAL ASSISTANCE (ON-GOING OR RECENT ACTIVITIES)

US National Park Service, Yellowstone Ecosystem, 1985-present; grizzly bear research & management.

US National Park Service, Southern Colorado Plateau, 1999-present; development of methods for inventory of biological resources; design of wildlife studies.

US Forest Service, Yellowstone Ecosystem & Tongass NF, 1991-present; grizzly bear management.

Interagency Grizzly Bear Committee, 1985-present; grizzly bear research & management and development & implementation of cumulative effects analysis (CEA).

Canadian Parks Service, Western Region, 1992-present; grizzly bear research & management.

Canadian Parks Service, Western Region, 1992-1995; implementation of ecosystem management and CEA.

Non-governmental organizations throughout western Canada and the western US, 1985-present; grizzly bear management, research & conservation.

Review of 42 manuscripts, 1991-present, for professional journals and presses, including Ecology, Journal of Wildlife Management, Conservation Biology, Journal of Mammalogy, Canadian Journal of Zoology, Biological Conservation, Journal of Applied Ecology, Journal of Range Management, Acta Theriologica, Ursus, Yale University Press, and International Conference on Bear Research & Management.

RECENT PRESENTATIONS (1991-PRESENT)

5 invited & 6 contributed papers at international professional conferences & workshops.

4 invited & 6 contributed papers at national professional conferences.

9 invited papers at regional professional conferences.

40 invited seminars, lectures, or courses at the University of Idaho, Yale University, Montana State University, University of Michigan, University of Montana, and The Yellowstone Institute.

8 invited presentations at management forums.

25 invited public lectures or presentations in venues including American Museum of Natural History, The Smithsonian, The Denver Museum of Natural History, Museum of the Rockies Winter Speakers Series, Cinnabar Symposium, and Public Interest Science Conference.

SELECTED RECENT PUBLICATIONS (1995-PRESENT)

Dobson, A., Ralls, K., Foster, M., Soulé, M.E., Simberloff, D., Doak, D., Estes, J.A., Mills, L.S., **Mattson, D**., Dirzo, R., Arita, H., Ryan, S., Norse, E.A., Noss, R.F. & Johns, D. 1999. Corridors: reconnecting fragmented landscapes. Pages 129-170 in M.E. Soulé & J. Terborgh, editors. Continental conservation. Island Press, Washington, D.C. (Invited chapter).

Mattson, D.J. 1995. The New World Mine and grizzly bears: a window on ecosystem management. Journal of Energy, Natural Resources & Environmental Law **15**: 267-293 (Invited).

Mattson, D.J. (1996). Modeling grizzly bear habitat suitability in Idaho. GAP Analysis Program Bulletin **5**: 18-19. (Invited paper).

Mattson, D.J. (1997). Use of ungulates by Yellowstone grizzly bears Ursus arctos. Biological Conservation **81**: 161-177.

Mattson, D.J. (1997). Use of lodgepole pine cover types by Yellowstone grizzly bears. Journal of Wildlife Management **61**: 480-96.

Mattson, D.J. (1997). Sustainable grizzly bear mortality calculated from counts of females with cubs-of-the-year: an evaluation. Biological Conservation **81**: 103-111.

Mattson, D.J. (2000). Brown bears. In press, in R.A. Reading & B.J. Miller (ed.). Endangered animals: conflicting issues. Greenwood Press, Westport, Connecticut. (Invited chapter).

Scott, J.M., Norse, E.A., Arita, H., Dobson, A., Estes, J.A., Foster, M., Gilbert, B., Jenson, D.B., Knight, R.L., **Mattson, D**. & Soulé, M.E. (1999). The issues of scale in selecting and designing biological reserves. Pages 19-37 in M.E. Soulé & J. Terborgh, editors. Continental conservation. Island Press, Washington, D.C. (Invited chapter).

Merrill, T., **Mattson, D.J**., Wright, R.G. & Quigley, H.B. (1999). Defining landscapes suitable for restoration of grizzly bears Ursus arctos in Idaho. Biological Conservation **87**: 231-248.

Mattson, D.J., Kendall, K.C. & Reinhart, D.P. (2000). Whitebark pine, grizzly bears, and red squirrels. In press, in D.F. Tomback, S.F. Arno & R.E. Keane, editors. Whitebark pine communities: ecology and restoration. Island Press, Washington, D.C. (Invited chapter).

Mattson, D.J., Herrero, S., Wright, R.G. & Pease, C.M. (1996). Science and management of Rocky Mountain grizzly bears. Conservation Biology **10**: 1013-1025.

Pease, C.M. & **Mattson, D.J**. (1999). Demography of the Yellowstone grizzly bears. Ecology **80**: 57-975.

Erika Nowak

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EDUCATION

1998 Northern Arizona University, MS, Biology

1991 Cornell University, BS, Wildlife Biology

HERPETOLOGICAL WORK EXPERIENCE

November 1992 to Present

WILDLIFE BIOLOGIST (RESEARCH TECHNICIAN) FROM 11/92 TO 6/98, USGS Forest and Rangeland Ecosystem Science Center/ Colorado Plateau Field Station at Northern Arizona University, Flagstaff, Arizona. Supervisors: Charles van Riper III, Station Leader, and Charles A. Drost, Zoologist

* Beginning a study of the status, distribution, habitat use, and prey preference of a rare garter snake in Oak Creek Canyon. Initiated Passive Integrated Transponder (PIT) tag monitoring programs for rattlesnakes at Montezuma Castle and Tuzigoot National Monuments and Northern Arizona. Conducted inventories and assessments of the herpetofaunas of Montezuma Castle National Monument and Petrified Forest National Park using standard herpetological techniques. Prepared proposals, annual reports, presentations, and final reports for these projects using DOS, Windows, and UNIX-driven word processing, database, statistical, and mapping programs. Collected distributional and seasonal abundance information for reptiles and amphibians based on personal and park staff observations. Conducted first two years of monitoring program for herpetofauna at Montezuma Castle. Writing an illustrated guide to the natural history and identification of the herpetofauna of Montezuma Castle National Monument and Petrified Forest National Park for use by park staff and visitors. Collected and prepared voucher specimens. Assisted with proposal development for additional surveys of the grassland herpetofauna of southern Colorado Plateau National Parks (funding requested). Served on Quality Circles to develop an in-house award system and to determine networking needs for this Field Station. Organized the Colorado Plateau Field Station's Producer of the Year Award for researchers.

March 1995 to April 1998: **HERPETOLOGIST**, USGS Forest and Rangeland Ecosystem Science Center/ Colorado Plateau Field Station at Northern Arizona University, Flagstaff, Arizona. Supervisor: Kathy Davis, National Park Service - Southern Arizona Group Office, Phoenix, AZ.

* Principal Investigator for telemetry study of eight free-ranging rattlesnakes at Tuzigoot National Monument (Arizona). Developed proposal, supervised one field technician, assisted with implantation of transmitters and field data collection from telemetered and untelemetered rattlesnakes, and produced maps and text for final report. Determined movement patterns, range size, habitat use, behavior, and hibernation and foraging sites for this population. Used GIS-based technology to record and map rattlesnake positions, activity ranges, and movements. Developed text and images for interactive computer program detailing rattlesnake natural history, snakebite,

conservation, and results of the telemetry research for monument visitor center. Submitted proposal for further research on this population to the Arizona Game and Fish Department Heritage Fund.

August 1994 to May 1998: **GRADUATE STUDENT**, Northern Arizona University, Flagstaff, Arizona. Major Advisors: Dr. Charles van Riper and Dr. Kiisa Nishikawa

* Conducted Master's thesis at Northern Arizona University on the effects and effectiveness of rattlesnake relocation at Montezuma National Monument (Arizona). Radio-tracked 19 western diamondbacks between 1994 and 1996 about every two days during active periods and weekly during hibernation. Determined movement patterns, range size, behavior, hibernation and foraging sites, and thermal ecology for this population. Used GIS-based technology to record and map rattlesnake positions, activity ranges, and movement patterns. Developed interpretative trailside display and brochures detailing rattlesnake natural history, behavior, and results of the telemetry research for monument visitor center.

May 1992-October 1992: **VOLUNTEER**, Malheur National Wildlife Refuge, Princeton, Oregon. Supervisor: Gary Ivey, Wildlife Biologist

* Designed and analyzed a herpetological survey in upland and aquatic habitats. Presented informal talks on the natural history of reptiles and amphibians of the refuge. Conducted surveys of nests, broods, and adults of waterfowl and sandhill cranes. Captured and banded waterfowl and sandhill cranes. Conducted radio telemetry of sandhill crane colts from hatching until fledging. Conducted surveys of raptors, shorebirds, other breeding birds, and coyotes. Staffed visitor center reception desk. Cared for ill waterfowl and raptors.

September 1991-March 1992: **INTERN**, Archbold Biological Station, Lake Placid, Florida. Supervisors: Dr. John Fitzpatrick, Director, Dr. James Layne, Vertebrate Ecologist, and Dr. Glen Wolfenden, Ornithologist

* Designed and completed a herpetological census of a cattle ranch using standard herpetological techniques and mechanical dredging. Supervised drainage ditch dredging and the capture and processing of animals in the ditches. Collected and prepared specimens inclusion in museum. Analyzed the relative effectiveness of drainage ditches in providing habitat for reptiles and amphibians. Recorded minute-by minute location and social and feeding behavior of scrub jays. Sampled insect populations monthly. Compiled and indexed 20 years of field observations and data, and more than 40 years of anecdotal and scientific field observations of the feeding and social behavior of crested caracaras. Acted as interpreter for several high school groups viewing scrub jay research.

John R. Spence

Botanist, Resource Management Division, Glen Canyon National Recreation Area
Glen Canyon National Recreation Area
National Park Service

EDUCATION

1977	Utah State University , B.Sc., Biology,
1980	Utah State University , M.Sc., Biology (Ecology)
1986	University of British Columbia , Ph.D., Botany,

CURRENT POSITIONS

Regional Coordinator, North Kaibab District, Arizona Breeding Bird Atlas Project
Adjunct Faculty Member, Dept. of Biological Sciences, Northern Arizona University
Adjunct Faculty Member, Department of Rangeland Science, Utah State University
Visiting Scientist, National Herbarium, Royal Botanic Gardens, Sydney, NSW, Australia
Participant, Flora of North America Project
Participant, Flora of Arizona Project

WORK EXPERIENCE (NPS only)

National Park Service, Glen Canyon National Recreation Area, 1992-present. Work on the structure and dynamics of riparian vegetation, hanging gardens, rare plant demography, and monitoring of threatened and endangered plant species. Extensive work on waterfowl and breeding bird surveys on the Colorado River and Lake Powell. Designed and implemented a Lake Powell waterbird survey.

Principal Investigator on GCES/GCMRC project on establishing a monitoring program for breeding riparian avifauna along the Colorado River from Glen Canyon Dam to Lake Mead, 1996-99. Established and monitored point count stations, conducted total surveys, trained field crews, and established habitat monitoring program. Co-Principal Investigator (1996) and cooperator (1997) on GCES/GCMRC project Transition monitoring of riparian vegetation from Glen Canyon Dam to Pearce Ferry, 1996-97. Extensive experience with the riparian vegetation and avifauna along the Colorado River.

Regional Coordinator, North Kaibab District, Arizona Breeding Bird Atlas Project, 1993-2000. Have conducted breeding bird surveys throughout the North Kaibab District, including 53 priority breeding blocks. Extensive experience with the avifauna of the region.

SELECTED GRANTS (Total 1987-2000: $1,300,000)

Post-doctoral Research Fellowship in alpine ecology, Hellaby Trust Fund, New Zealand, 1987-1989 ($71,000).

Australian Biological Resources Study Participatory Program on Flora of Australia, 1990-1992 ($49,000).

National Park Service, Water Resources Division grant on "Recovery of riparian vegetation following removal of livestock, Glen Canyon National Recreation Area", 1995-96 ($35,000).

National Park Service, Competitive and Cooperative Research grant on "Inventory, classification and grazing on Rangelands in Glen Canyon National Recreation Area", 1996-98 ($60,000).

National Biological Service, "Species at risk initiative" grant on "Survey of federal candidate plant species on the Tropic Shale and Carmel Formations, south-central Utah, 1996 ($7,000).

National Park Service, Water Resources Division grant on "Wetland inventory and classification using multi-spectral videography in Glen Canyon National Recreation Area", 1996-97 ($44,000).

Glen Canyon Environmental Studies, Bureau of Reclamation, Transition monitoring of riparian vegetation from Glen Canyon Dam to Pearce Ferry, 1996 ($100,000).

Glen Canyon Environmental Studies, Bureau of Reclamation, Transition monitoring of riparian vegetation from Glen Canyon Dam to Pearce Ferry, 1996 ($100,000).

Grand Canyon Monitoring and Research Center. Proposal to monitor riparian vegetation from Glen Canyon Dam to Pearce Ferry. Northern Arizona University proposal , 1998-00 ($245,000).

USGS/BRD-NRPP. Proposal to develop new grazing effects methods for monitoring at Glen Canyon NRA, 1999-2002 ($210,000).

PUBLICATIONS (45 peer-reviewed papers in areas of specialty; recent NPS reports/papers):

LaRue, C.T., L. Dickson, N. Brown, J.R. Spence and L. Stevens. 2000. New and interesting birds from the Grand canyon region. Submitted to *Western Birds*.

Spence, J.R., C.T. LaRue, J.R. Muller and N.L.Brown. 1998. 1997 avian community monitoring along the Colorado River from Lees Ferry to Lake Mead. Final Report submitted to Grand Canyon Monitoring and Research Center. National Park Service.

Spence, J.R. 1997. Breeding bird surveys along the Colorado River, Glen Canyon, Arizona. 1996 summary progress report and evaluation of the long-term monitoring program. Final Report to Grand Canyon Monitoring and Research Center. National Park Service.

Petterson, J. and Spence, J.R. 1997. 1996 avian community monitoring in the Grand Canyon. Final Report to Grand Canyon Monitoring and Research Center, Bureau of Reclamation. National Park Service.

Spence, J.R. 1996. A survey and classification of the riparian vegetation of selected side canyons of Lake Powell, Glen Canyon National Recreation Area. Final report, Resource Management Division.

Kearsley, M.J.C., J.R. Spence, T.J. Ayers, K.M. Christensen, P.R. Rowlands, N. Brian, and A.M. Philips.1996. Bridging the gap: transition monitoring of riparian vegetation from Glen Canyon Dam to Pearce Ferry. Final Report submitted to Grand Canyon Monitoring and Research Center. 59 pp.

Spence, J.R., W.H. Romme, L. Floyd-Hanna, and P.G. Rowlands. 1995. A preliminary vegetation classification for the Colorado Plateau. pp. 193-213 In: Van Riper III, C. (ed.). Proceedings of the Second Biennial Conference on Research in Colorado Plateau National Parks. Trans. and Proceed. Ser. NPS/NRNAU/NRTP-95/11.

Spence, J.R. 1995. Characterization and possible origins of isolated Douglas Fir stands on the Colorado Plateau. pp. 71-82 in Climate change in the Four Corners Region. Proceedings of a symposium, Grand Junction, September 12-14, 1994.

Spence, J.R. and S. Borthwick. 1995. A preliminary account of the birds of Capitol Reef National Park, southern Utah. *Utah Birds* 11: 1-12.

Spence, J.R. and N.R. Henderson. 1993. Tinaja and hanging garden vegetation of Capitol Reef National Park, south-central Utah, U.S.A. *Journal of Arid Environments* 24: 21-36.

Kathryn Thomas

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AREAS OF EXPERTISE

Plant species and vegetation distribution and dynamics in the southwest

Invasive plant species

Use of GIS in vegetation management and for conservation planning

Quantitative methods in vegetation classification, mapping and monitoring

EDUCATION

1996 University of California at Santa Barbara, Santa Barbara, CA. Doctor of Philosophy in Geography

1985 University of California at Davis, Davis, California. Master of Science

1973 University of Oregon, Eugene, Oregon. Bachelor of Science, Biology

RESEARCH EXPERIENCE

Vegetation Ecologist (1995-present), Colorado Plateau Field Station, Biological Resources Division, U.S. Geological Survey, Flagstaff, AZ. 86011.

Research Assistant (1986-1995), University of California at Santa Barbara, Santa Barbara, CA. 93106.

Lecturer, University of California at Santa Barbara, Santa Barbara, CA 93106. (1989/90)

Teaching Assistantships, University of California at Santa Barbara, Santa Barbara, CA 93106. (1986/87/88/89/90/91)

Landscape Analyst (1990-1995), University of California at Santa Barbara, Santa Barbara, CA 93106.

Environmental Consultant (1990-1995), various locations, California

Educational Coordinator, University of California International Education, Davis, California. 1986.

FUNDED PROPOSALS AND PROJECTS (SINCE JOINING CPFS)

1999-04 - SW Regional Gap Analysis Program in Arizona; Project Leader

1999-01 - Description and classification of Vegetation at the Three Flagstaff National Monuments; Project Leader.

1999-04- USGSS Global Change Program: Vegetation Response Project; Project Leader.

1998-99- Open Space Analysis in Yavapai and Southern Mojave Counties, Arizona; Project Leader.

1997-01 - Recoverability and Vulnerability of Desert Ecosystems; Project Team Member

1997-00 - Southwest Exotic Plant Mapping Program; Project Leader.

1997 - Exotics Map Project for the Colorado Plateau; Project Leader

1997-1999 - Mojave Desert Ecosystem Program: Mojave Vegetation Mapping Project; Co-Project Leader

1996-99 - Vegetation Studies of the Petrified Forest National Park; Project Leader.

1996-98 - Gap Analysis Program: Accuracy Assessment of Northern Arizona GAP Vegetation Coverage and Vertebrate Models; Project Leader.

1996-98 - Standard Vegetation Survey and Classification for Death Valley National Park and the Mojave National Preserve, Project Leader.

PUBLICATIONS

Thomas, K., T. Keeler-Wolf, J. Franklin. 2001. A Comparison of Fine and Coarse Resolution Environmental Variables toward Predicting Vegetation Distribution in the Mojave Desert. *In* Predicting species occurrences: issues of scale and accuracy, (Scott, J.M., P.J. Heglund, M. Morrison, M. Raphael, J. Haufler, B. Wall, editors). Island Press. Covello, Ca.

Franklin, J., T. Keeler-Wolf, **K. Thomas**, D. Shaari, P. Stine, J. Michaelsen, J. Miller. 2000. Stratified sampling for field survey of environmental gradients to define vegetation alliances in the Mojave Desert Ecoregion. Eds. Millington, A., S. Walsh, P. Osborne. In: GIS and Remote Sensing applications in Biogeography and Ecology.

Thomas, K. A. and F. W. Davis. 1996. Applications of gap analysis data in the Mojave Desert of California. In: A Gap Analysis: A landscape approach to biodiversity planning. Proceedings of the ASPRS/GAP Symposium, February 27- March 2, 1995, Charlotte, North Carolina@. (Eds. J.M. Scott, T.H. Tear and F. Davis). The American Congress on Surveying and Mapping and the American Society for Photogrammetry and Remote Sensing, Bethesda, MD.

Thomas, K. A. 1996. Vegetation and Floristic Diversity in the Mojave Desert of California: A regional conservation evaluation. Dissertation. University of California, Santa Barbara, California.Ferren, W. R. and K. A. Thomas. 1995. University of California, Santa Barbara Natural Areas Plan: Classification, inventory, and management guidelines. Museum of Systematics and Ecology, Department of Biological Sciences, University of California, Santa Barbara, CA 93106. 438 pg.

Thomas, K. A. and A. M. Berry. 1989. Internal and external nitrogen inhibition of nodulation on *Ceanothus griseus* var. *horizontalis,* Plant and Soil 118:181-87.

Ferren, W. R. and **K. A. Thomas**. 1995. University of California, Santa Barbara Natural Areas Plan: Classification, inventory, and management guidelines. Museum of Systematics and Ecology, Department of Biological Sciences, University of California, Santa Barbara, CA 93106. 438 pg.

Thomas, K. A. and A. M. Berry. 1989. Internal and external nitrogen inhibition of nodulation on *Ceanothus griseus* var. *horizontalis,* Plant and Soil 118:181-87.

Professional Memberships

Ecological Society of America

International Association for Vegetation Science

California Botanical Society