Grand Canyon National Park
Science Information Needs
(Revised 3/11/98)

This document represents a prioritized list of topics recommended for future scientific study in Grand Canyon National Park. Suggestions have come principally from park management and scientists familiar with the resources and issues. Our approach has been to organize information needs first by ecosystem, then by subject within the affected ecosystem. Similar topics are grouped, but the order of listing does not indicate priority. All topics in this list are considered appropriate for further study. Group headings may be repeated, but we have tried not to repeat a particular information need in more than one place.

Fifty topics are identified in **bold face type**. These include both broad and highly focused questions, most dealing primarily with issues important for resource and visitor management, or essential to a better understanding of resource condition. Some of these are new topics, added since the last revision of this list (October, 1996). Others represent studies already planned or underway but for which more work is needed.

Priorities will be reviewed and revised annually as needed. Any comments or questions about this list should be addressed to the Senior Scientist.

A "*" indicates that topic will be partially or fully addressed by currently planned work in FY 98, 99, or 2000.

Contents

I. Park wide Information Needs Identified by Discipline

A. Ecosystem Management

Specific Information Needs

Comprehensive resource inventory, monitoring, and research plan. Develop a conceptual model, identify indicator resources, establish monitoring standards, and develop peer-reviewed protocols for field work, data analysis, and reporting. *(Supports GPRA goal #10, Servicewide goal Ib1).*

* Develop energy flow and material cycling models for a park-wide energetics model

Climate studies for long-term global change analyses in this world-class park. Integrate present climate data. Develop and maintain climate station at 3 South Rim locations, 3 North Rim locations, 3 mid-elevation locations, 3 river locations (Lees Ferry station should be upgraded and maintained, Phantom station is running, Diamond Creek station is needed). Develop an integrated mesoscale climate model for GRCA.

B. Cultural Sciences, Anthropology, and Archaeology

Grand Canyon contains abundant evidence of human occupation spanning the last 10,000 years of human habitation. Although the majority of known sites represent Puebloan occupations form A.D. 800-1100, limited evidence suggests the possibility of a Paleo-Indian presence, as well as good documentation for an Archaic occupation, Basketmaker, Pueblo II-III, and protohisotirc occupations through the present. The park has a strong cooperative program to locate, characterize and preserve cultural sites within the Colorado River corridor, and recognizes the need for comprehensive archaeological inventories throughout the rest of the park, especially in high-use areas. Development of a model archaeological research design for scientific investigations of prehistoric sites, patterns of occupation, and human ecology within the canyon and surrounding areas is currently a top priority. Regional ethnographic and traditional-use studies are also needed to document tribal interests (i.e., Hopi, Navajo, Hualapai, Havasupai, Southern Paiute, Zuni, etc.) for Grand Canyon and other National Park Service areas on the Colorado Plateau. Other research needs include a determination of the effects of forest fire on archaeological sites and data recoveries for site-specific mitigation.

Specific Information Needs

* **Archaeological research design.** Develop and implement archaeological research design(s) applicable to investigations of archaeological sites throughout the park.

Ethnographic studies. Conduct an ethnographic overview and assessment of tribal interests and uses of the parks on the Colorado Plateau (i.e., Hopi, Navajo, Southern Paiute, Hualapai, Havasupai, Zuni, etc.) These studies have application to several NPS areas and should be specific to each tribe, rather than to the particular park. *(Supports GPRA goal #15, Servicewide goal Ib2E).*

Archaeological site inventories. Conduct comprehensive archaeological inventories of developed and high use areas (i.e., campgrounds, trails, road corridors, etc.) *(Supports GPRA goal #11, Servicewide goal Ib2A).*

Tribal use studies. This subject deals exclusively with traditional uses, collections, ceremonials, etc. which occur within the landscape of NPS units. The study should be tribe specific, and applicable to all NPS units within the tribes areas of concern.

Grand Canyon National Park history. Develop a comprehensive history of CCC activities within the park to support National Register nomination as a multiple property district.

Cultural landscape studies. Identify, document, and evaluate cultural landscapes, beginning with areas identified in the Grand Canyon National Park General Management Plan and incorporating NPS-28 defined categories which occur within the park. *(Supports GPRA goal #8, Servicewide goal Ia7).*

Data recovery. Site-specific mitigation plans for impacted sites within GRCA backcountry. Site priorities should be established from the Backcountry Management Plan, with Clear Creek and Boucher as likely first priorities.

C. Natural Resources

The great diversity of ecosystems within Grand Canyon National Park support a wide variety of vertebrate and invertebrate wildlife, including large and small mammals, migratory and resident birds, reptiles, amphibians, and invertebrates. The enormous size of the park (1.2 million acres), extremely variable terrain, and logistical difficulties of wilderness research have limited knowledge about the abundance, distribution, and life history of many species within the park. Current information needs include wildlife inventories and basic life history data for many species, as well as studies directed towards the preservation of rare and special status species.

Specific Information Needs

Special Status Species. Study population status and trends for Federally-listed and other rare or declining native species. *(Supports GPRA goal 3 and 4, Servicewide goals Ia2A and Ia2B)*

* **Mexican spotted owls (GRCA-N-220.102)**

* **Sentry milk-vetch**

* **Northern goshawk**

* **Peregrine falcon (GRCA-N-220.105)**

* Other species

Resource inventory databases. Expand or complete basic NPS resource inventory datasets, towards development of a comprehensive GIS-based atlas of Grand Canyon resources. *(Supports GPRA goal #10, Servicewide goal Ib1).*

* **expand computerized natural/cultural/social resource bibliographies** *(basic NPS I&M dataset)*

* animal species checklist *(basic NPS I&M dataset)*
* animal species distributions *(basic NPS I&M dataset)*
animal population dynamics

* surface vegetation map *(basic NPS I&M dataset)*
* plant species checklist
* plant species distributions
plant species abundance

* digitized base cartographic data *(basic NPS I&M dataset)*
land use history (grazing, fire history, mining, hazmat sites, flight routes etc.)
locations of long term monitoring plots, stationary instrumentation

* soil maps *(basic NPS I&M dataset)*
* geologic exposure maps *(basic NPS I&M dataset)*
geologic activity maps (faults, debris flows, flooding)
* **cave database and maps**

* surface water quantity, hydrology *(basic NPS I&M dataset)*
* surface water quality *(basic NPS I&M dataset)*

sources of water pollution

* subsurface water quantity, hydrology
subsurface water quality
* extraction or injection well locations in priority aquifers

* air quality *(basic NPS I&M dataset)*
* sources of air pollution
meteorological (climate) data for key locations

Natural resource museum collection. Develop a synoptic reference collection that supports natural resource inventories through vouchers and comparative specimens. Identify holdings of other collections containing GRCA materials. Ensure professional evaluation of of each resource type within the collection by academic subject matter specialists (e.g., geology, botany, zoology) to identify unknowns and to guide further development of the collection.

Natural resource inventories and monitoring

Relict vegetation surveys. Much of the remote backcountry of Grand Canyon has never been systematically explored. Surveys are needed throughout the park to locate and characterize relic areas of unaltered natural vegetation. Opportunities for investigating previously undescribed communities are good.

Geologic resource inventory. Locate through literature searches and fieldwork significant geologic exposures that may be at risk of loss due to human or natural causes (e.g. vertebrate fossils, trackways and other trace fossils, rare minerals, or crystals). Characterize the specimens through photography and other means in a GIS database. Recover specimens for museum collections if deemed appropriate due to risk.

* Herpetofauna Surveys. (GRCA-H-210.109)

Inventory, assess and monitor sensitive plant species including cryptobiotic soil crusts

* Inventory and monitor carnivores (GRCA-N-210.109)

* Inventory and monitor upland birds (GRCA-N-210.103)

Monitor Kaibab squirrel population trends (GRCA-N-220.101)

* Inventory & monitor bighorn sheep (GRCA-N-210.110)

* Monitor native grazing herbivores and forage base carrying capacity

* Monitor introduced grazing herbivores and forage base carrying capacity

Exotic flora and fauna. Investigate routes of entry, colonization and suitable management alternatives to control infestations and limit damage to native species and other park resources.

* Delineate wetlands in areas of development (GRCA-N-310.201)

* Invertebrate studies in all GRCA habitats

* Non-vascular plant inventories: including mosses, lichens, and fungi.

Integrate vegetation data with the newly developed national vegetation classification program

Investigate Feasibility of Restoration and Reintroduction *(Supports GPRA goals #1 and #2, Servicewide goal Ia1A, and Ia1B)*

* Monitor and control cowbirds at corrals & stock areas (GRCA-N-220.104) (studies underway in 1996)

Prairie dogs. Investigate feasibility of reintroduction in conjunction with USFWS.

* Reintroduction of California condors (GRCA-N-270.102) (Vermilion Cliffs releases are underway with USFWS)

Burrowing owls. Investigate feasibility of reintroduction in conjunction with USFWS.

Wolves. Investigate feasibility of reintroduction in conjunction with USFWS.

D. Social and Recreation Science, Visitor Use

Understanding park visitors, their needs, motivations, and how they use or abuse their parks is a basic need for informed management. Information about visitors,

use patterns, perceptions, etc. is currently needed to support revisions of the backcountry, wilderness, river, and aviation management plans. Information needs in these areas include visitor surveys, resource impact studies, and management alternatives.

Specific Information Needs

* **Acoustic monitoring.** Design and operate an acoustic monitoring system for overflights by aircraft tour operators. Conduct data management and interpretation of acoustic monitoring data from past studies.

Visitor characteristics and use patterns surveys. Monitor expectations of park visitors on the rim, in the backcountry, on the river, and in the air. Know what the public expects at Grand Canyon, where they come from, and how they spend their time and money. Include foreign visitors and Lees Ferry anglers in visitor studies.

* **Backcountry day-users**

* **River users**

Backcountry overnight users

Rim (i.e., front country)users

River use allocation

Evaluate alternative strategies for equitable allocation of river use permits.

* Develop or refine a river travel simulation model

Monitor visitor impacts to park resources

Visitor impacts to day-use resources

* Visitor impacts to river resources

Visitor impacts to backcountry resources

Visitor impacts to Rim resources

Anthropogenic wildlife effects studies. Document effects of aircraft, research, trail maintenance, patrols, rescues, etc. on wildlife and other sensitive park resources. (GRCA-N-250.102) Investigate and develop

management alternatives for minimizing hazardous interactions.

Visitor safety *(Supports GPRA goal #17, Servicewide goal IIa2)*

Visitor incident analyses. Conduct a statistical analysis of the GRCA Search and Rescue (SAR) database. Determine trends and identify opportunities to put the information to use to improve visitor safety.

Safety monitoring on the river, in the backcountry, and on the rim. Determine what are the risks and the costs. What risks can be reduced without compromising natural values. Evaluate visitor preparedness.

* Heat stress monitoring. Monitor or model ambient temperature, solar radiation, humidity, and other climatic factors on principal trail systems in the inner canyon. Purpose is to provide improved management capability to reduce visitor incidents related to heat stress.

Regional economic analyses of recreation

E. Administrative and Legal Topics

Legal boundary studies. Research legal and administrative history of GRCA-Reservation boundaries (GRCA-C-130.002) (New Solicitors opinion issued in 1998.)

Administrative park history (GRCA-C-310.014) (study underway by GCA)

Administrative issues history. Develop a comprehensive administrative issues history so that a comprehensive understanding of the challenges, strategies, and outcomes of management actions can be preserved.

* Assemble information to support NPS water rights claims (LCR studies initiated in 1996)

Consolidate and summarize law, treaties, and administrative mandates affecting GRCA, including any state, local, and tribal authorities

Prepare administrative history of natural resources management and research (GRCA-C-310.020)

II. Information Needs Identified by Ecosystem

F. Colorado River and Riparian Ecosystems

Completion of Glen Canyon Dam in 1963 greatly moderated downstream flows in the Colorado River. The frequency and magnitude of river flooding was sharply reduced, seasonal flow patterns altered (reduced in spring and summer, increased in fall and winter), suspended sediment nearly eliminated (except for downstream tributary inputs), seasonally-variable water temperatures stabilized (to an average 46°F at the dam and 55-60°F at Diamond Creek), and the natural migratory routes of fish and wildlife were blocked. Resultant changes to downstream ecosystems have been enormous. Of eight species of native fish present when Glen Canyon Dam was constructed, three species including roundtail chub and the endangered Colorado squawfish and bonytail chub have been extirpated. Two species (razorback sucker and humpback chub) are listed as endangered. (Three other native species, bluehead sucker, flannelmouth sucker, and speckled dace, remain relatively common.) In the near absence of annual flooding riparian vegetation has increased greatly, including native marsh plants and the exotic salt cedar. With the reduced frequency and magnitude of flooding, and the loss of sediment trapped in Lake Powell, beach building processes have been greatly diminished and erosion of archaeological sites and camping beaches has accelerated. Current information needs in the river corridor include surveillance and monitoring of resources, and mitigative measures to preserve and restore sensitive species, cultural sites, and high-quality recreational opportunities. Studies are also needed to improve our understanding of riverine ecology and the effects of basic environmental conditions, including flooding, sedimentation, erosion, and water temperature. Investigate anthropogenic forces, environmental processes, and resource condition (keystone and indicator resources, status, cycles, and long-term trends) from the Glen Canyon Dam forebay to the headwaters of Lake Mead. Utilize modeling, remote sensing, indicator resources, and statistical sampling systems to reduce impacts of research on wilderness experience and resource condition. *(Supports GPRA goal 1, Servicewide goal Ia1A)*

Specific Information Needs (Important ongoing studies, mostly funded through ongoing programs)

Riverine processes. Monitor the primary physical factors controlled by dam operations and initial ecological responses to dam operations (riparian climate, erosion, sediment transport and deposition, photosynthetic production, downstream water temperature, water quality, etc.)

* Rare and special status biota. Study population status and trends for all Federally-listed species in the Colorado River and riparian area potentially

affected by operations of Glen Canyon Dam *(Supports GPRA goal 3 and 4, Servicewide goals Ia2A and Ia2B).*

* **Kanab ambersnail** (GRCA-N-230.102). Study genetics and ecology. Monitor changes to populations, and determine potential for secondary populations within and outside the Grand Canyon.

* **Southwest willow flycatcher** (GRCA-N-230.100, GRCA-N-220.103)

* **Humpback chub** (GRCA-N-220.106). Determine current status and long term trends in adult population, health, reproduction, and recruitment in the CR main channel, LCR, and other tributaries.

Other natural resources

* **Vegetation.** Monitor distribution and abundance of native and non-native riparian vegetation, including Federal, state, and tribal listed sensitive species, old high water zone, new high water zone, and near shore marshes

* **Food web.** Determine status and trends in species composition and population structure of ecologically important food web organisms originating from aquatic and riparian sources, and influence of ecologically significant processes.

* **Fisheries resources.** Study reproduction, recruitment, population dynamics, distribution, frequency of occurrence, diet, and other life history traits of native and non-native fish species in the Colorado River between Glen Canyon Dam and Lake Mead.

    * Flannelmouth sucker, bluehead sucker, speckled dace and other native species (GRCA-N-210.101)

    * Salmonids, ictalurids, cyprinids, and other non-native species, and impacts

    * Experimental removal of exotic predators and competitors in critical habitats of declining native fishes

Colorado River pikeminnow (GRCA-N-270.102). Investigate feasibility of reintroduction in conjunction with USFWS.

Bonytail chub (GRCA-N-270.101) Investigate feasibility of

reintroduction in conjunction with USFWS.

Roundtail chub. Investigate feasibility of reintroduction in conjunction with USFWS.

* **Wildlife resources.** Monitor distribution, abundance, and population structure of wildlife species with the Colorado River corridor, including resident and migratory birds, mammals, herpetofauna, and invertebrates.

* **Sediment resources.** Monitor distribution, elevation, open area, longevity, and other characteristics of sand bars and beaches, including those suitable for camping and associated backwater areas.

Models and trend data. Develop information systems, conceptual, and mathematical models for evaluating alternative operations of Glen Canyon Dam under the Adaptive Management Program.

* **Conceptual ecosystem model.** Identify principal ecological and anthropogenic forces, keystone physical and biotic resources, and indicators of resource condition (natural, cultural, recreational).

* **Flooding and alternative flows model.** Evaluate through modeling and experimentation, the beneficial and deleterious effects of floods and flood exclusion on natural, cultural, and recreational resources within the Colorado River from Glen Canyon Dam to Lake Mead.

* **Sediment transport model.** Model and measure sediment contributions to the CR from all significant sources, determine the amount of sediment needed to maintain sandbar, backwater, and bank deposits, and track sediment supplies available for redistribution through flow manipulation.

* **Selected temperature withdrawal model.** Evaluate the feasibility of long-term and short-term changes to discharge water temperature from Glen Canyon Dam and the potential effects on distribution, reproduction, recruitment, and survival of native and non-native fishes, on the aquatic food base, and on other resources (GRCA-N-230.101)

River corridor cultural resources. Monitor cultural sites potentially impacted by Glen Canyon Dam operations to determine present condition, rate of change due to erosion, bank collapse, etc. Develop mitigative measures to ensure long term site integrity and recover data as needed. Conduct comparative analysis of cultural sites to control sites to determine relative effects of river influence and

geomorphology on site erosion. (Important ongoing studies, being accomplished through current programs).

* Monitor archaeological sites

* Identify traditional cultural property sites

G. Forest Ecosystems

After nearly 100 years of fire suppression in Northern Arizona forests, dangerously high fuel loads have accumulated because of under story vegetation, dead fall, and crowding. Tree density in ponderosa pine forests that once averaged 40 trees per acre (1869) have increased to a present day 850-1000 trees per acre. The potential for catastrophic stand-replacing fires is extremely high. Although prescribed burns and managed natural fire can reduce fuel load in limited areas, broad application of these techniques within the park is limited, notably by protection of cultural sites, sensitive wildlife species, air quality, and safety issues. The highest priority for fire research in National Parks is to provide information for fire management decisions. Areas at high risk of catastrophic fire are identified and present-day options evaluated through close cooperation of scientists and park management. Innovative long-term management alternatives to fire suppression and limited prescribed fire regimens are also needed. The effects of wildfire, fire suppression and prescribed fire on human safety, wildlife, archaeological sites, and other important resource values (e.g., air quality, scenic vistas, etc.) should be documented and evaluated in an ecosystem context, so that appropriate protective and mitigative measures can be developed and relative advantages weighed. Forest ecology studies are needed to describe the frequency, magnitude, and distribution of presettlement natural fires in several vegetative community types and numerous locations. Changes in vegetation, species occurrence, abundance, and population structure, that can be attributed to fire suppression, grazing, exotic species, and natural succession (forest, meadow, scrub, etc.) should be documented over time, and projected into the future.

Specific Information Needs

* **Biological monitoring (fire)**. Develop a prescribed fire biological monitoring program, including evaluation of the existing fire effects monitoring programs, and consideration to potential applications in other areas. (GRCA-N-230.105)

* **Management alternatives for forest ecosystem restoration.** Develop improved and alternative management strategies to reduce risk of resource damage from catastrophic fires (in coniferous and mixed forests, Mojave mixed desert scrub, etc.). Prescribed fire, as currently implemented, can neither control the risk of wildfire, nor fully restore ecosystems to presettlement conditions.

During the past few years, park officials and subject matter experts have pointed to the need for innovative techniques. Scientific research, founded in modeling and cognizant of the need for practical applications will provide credibility to the use of such techniques. *(The following list of restoration and fire related information needs was developed during a joint meeting of the Grand Canyon Science Center and the Fire Management Office, February 11, 1998. The highest priority information needs are in bold type.)*

* **Effects of prescribed and natural fire including:**

Relationship of fire intensity to fire effects and restoration of Ponderosa Pine forests to include catastrophic wildfire.

Effects on biota with "out of season" burns including structure and species composition

Evaluating the effects of burn season and prescription on survival and vigor of old growth trees

Model the effects of forest restoration on wildlife populations

Fire ecology studies/literature review of ecosystems other than Ponderosa Pine such as aspen/spruce/fir/pinyon-juniper.

Research the natural (presettlement) fire regime for plant communities through fire scar analysis, and develop management recommendations based on findings.

Research the effects of fire exclusion and prescribed fire on park wildlife and the representative vegetation communities including grasslands (Kanab, Shivwits, Coconino, Plateaus). To maximize the value of applied research in this area, the broad subject areas would need to be narrowed considerably through discussion with park management. Include study of control sites.

Study fire ecology at low elevations. Increased fire frequency along the river and in formerly unburned tributaries is an important consequence of visitation and of increased Bromus (introduced grass cover)

Evaluate the correlation between prescriptions, actual conditions, and emissions produced compared to wildfire (to include duration etc.)

Establish a long term monitoring plan for experimental restoration sites

Develop annotated bibliography of useable information for fire use and other

restoration methods.

Cumulative effects watershed effects of prescribed fire and fire use (or lack thereof) versus wildfire

Development of management practices to protect wetlands, water quality, etc. after fire or because of fire.

Evaluate methods for sampling herbaceous vegetation, including but not limited to the NPS Fire Management Handbook.

Need to better assess effects of fire on archaeological resources (wildfire, prescribed fire, and fire use). The focus of this study should be applied to known and expected resource types within the proposed areas of prescribed fire. First priority should be a thorough literature search and direct communication with specialists in other locations (e.g., Mesa Verde), to help guide planning for any needed field studies..

Determine aboriginal use of fire and its effect on systems and/or perceptions of what is now

Evaluate alternative methods for removing unsightly restoration treatment effects in wilderness

Establish specific goals for use of prescribed fire and fire use, i.e., amount of fire vs. other methods, emission production vs. ecosystem health; fire as an ecosystem process

Identify specific post-fire watershed and soils issues. Establish thresholds for soil productivity after fire. Develop management approaches for restoration

Ethnographic study of plant use and impact from seasonality of fire use and prescribed fire.

Determine effects of fire on fungi, microbes in soil.

Develop an accepted definition of forest ecosystem restoration, and measurable standards for determining when it has been accomplished.

Compile and re-evaluate North Rim fire ecology data that Peter Bennett (Tucson CPSU) collected during the 1970's

H. Groundwater, Cave, and Karst Ecosystems

Grand Canyon National Park is located in the arid Southwestern United States. Park

ecosystems range from upland coniferous and semi-arid forests to Great Basin and Mojave deserts. Beyond the river corridor, availability of potable water is perhaps the parks most limited resource. Lack of readily available water has also greatly constrained the growth of communities outside the park boundaries. The primary source for potable water within the park, and for the gateway community of Tusayan, is the collection of groundwater issuing from Roaring Springs, a solution cave within the Redwall limestone formation. Numerous other springs and seeps throughout the canyon provide localized pockets of moisture essential to the survival of native plants and wildlife (including the endangered Kanab ambersnail). Human visitors to back country areas also depend on natural springs for drinking water. The capacity of the aquifer and locations and flow rates of remote seeps and springs is largely undetermined. Park management is concerned about groundwater development, and particularly about wells to be drilled south of Grand Canyon Village, because groundwater withdrawals may reduce or eliminate flows within the park. Research is needed to determine aquifer storage, sustainable yield, groundwater distribution patterns, and surface recharge conditions within the park and surrounding areas. The potential effects of mine-waste and other surface contaminants should also be quantified. Hydrologic and ecological studies are also needed for documenting flows and associated dependent flora and fauna at existing springs and seeps.

Grand Canyon National Park contains extensive karst formations, but very little of a specific nature is known about the cave resources. Park files contain locations and other general information for several dozen caves within the park that have been explored to some extent. However, few caves within the park have been systematically surveyed to identify significant physical, biological, and cultural resources, and the passages of only a few caves have been accurately mapped. Detailed scientific information is needed for hundreds of unexplored caves within the park. First priority should be inventories of known caves and establishment of long-term resource monitoring protocols, followed by exploration of wild caves and research to better understand the nature and significance of cave resources within the park.

Specific Information Needs

* **Groundwater studies.** Conduct detailed hydrogeologic studies of South Rim areas. Document real and potential effects of surface and ground water diversions within and outside of the park (Roaring Springs, Tusayan, S. Rim). Identify alternative sources of potable water.

* **Cave resource inventory and assessment.** Plan and implement cooperative program of study including biological, physical, paleontological and archaeological resources.

* **Bat population surveys** (GRCA-N-210.107)

* **Invertebrate surveys.** Inventory spring, seep, & wetlands invertebrates (GRCA-N-230.103)

* **Surface water flows.** Conduct legally-defensible analyses of flows and water-related values at various springs, streams, and major tributaries in order to participate effectively in future water right adjudications

* Compile and integrate surface water quality and quantity data. Review and refine present surface water monitoring program.