SOUTHERN PAIUTE CULTURAL RESOURCE MONITORING

IN THE *COLORADO RIVER CORRIDOR*

A Preliminary Chapter to be Incorporated
in the Third and Final Report

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May 1995

Report of work carried out under Southern Paiute Consortium Cooperative Agreement with
the Bureau of Reclamation, #4-FC-40-15260

BRIEF EXPLANATION

This chapter outlines a number of important considerations for choosing which archaeology sites, plants, rock art, and animals to monitor. It also includes a review of potential methods for monitoring both cultural and natural resources in the *Colorado River Corridor*. The contents of this chapter should therefore be reviewed by the Southern Paiute Consortium before the survey trip is conducted. The tentative dates and purpose of the survey trip are included as an outline below. In order to highlight both this upcoming fieldwork and the relevancy of monitoring to all of the ethnographic research that has been conducted, the monitoring chapter, which will be included as part of the final report, has been submitted here for early review.

Background

The Grand Canyon has deep spiritual and cultural meaning for the Southern Paiute people. It is imbedded in both their historical and contemporary ways of life. However, the incursion of European settlers into areas that were politically controlled by the various bands of the Southern Paiute Nation has limited their access to and control over the cultural and natural resources located in the *Colorado River Corridor*. This intrusion has not diminished the spiritual, religious and cultural importance of the Grand Canyon and the Colorado River to contemporary Southern Paiute people.

Glen Canyon Dam has seriously altered the riparian and aquatic ecosystems in the *Colorado River Corridor*. Consequently, Southern Paiute people are aware of the impacts occurring to the Grand Canyon as a whole, as well as to specific cultural and natural resources within the *Colorado River Corridor*. The Glen Canyon Environmental Studies (GCES) was created to assess the impacts of variable flow rates from Glen Canyon Dam on the riparian and aquatic habitats of the *Colorado River Corridor*. As part of this program, the Southern Paiute Consortium has been integrated into the long range monitoring of cultural and natural resources. The data acquired from the monitoring program will be analyzed in relation to other datasets, like human activity and water flow, in order to best assess a course of action to prevent future adverse impacts from occurring to both cultural and natural resources in the *Colorado River Corridor*.

Between 1992 and 1995, representatives of the Southern Paiute Consortium participated in ethnographic inventories of archaeology sites, plants, rock art, and animals in the *Colorado River Corridor*. These trips were not only fruitful for ethnohistorical and educational reasons, but also for the concerns and recommendations that the Southern Paiute representatives expressed about their cultural resources in the *Colorado River Corridor*. These concerns and recommendations are to be incorporated into the long range monitoring program in two ways: (1) through on-site monitoring; and (2) through the integration of data concerning Southern Paiute cultural resources into the GCES Geographic Information System (GIS). This GIS database, which is housed at the GCES offices in Flagstaff, provides a central location for analyzing a wide variety of spatially referenced data about the *Colorado River Corridor* (see **Southern Paiute Resources and the GCES-GIS** below).

The concerns and recommendations that the Southern Paiute representatives have expressed about their cultural resources in the *Colorado River Corridor*, provided the basis for the monitoring framework that is presented here. Ethnographic research has been conducted for four types of cultural resources (archaeology sites, rock art, plants, and animals) in the *Colorado River Corridor*. This chapter is therefore relevant to all the ethnographic research that has been conducted in the past. In early June 1995, a survey trip will be conducted from Lees Ferry to Diamond Creek in order to acquire monumentation and locational data for potential Southern Paiute cultural resource monitoring sites.

Survey Trip Purpose

The survey river trip has two purposes: (1) to permit representatives of the Southern Paiute Consortium to work with GCES surveyors so that the exact boundaries of places and things of cultural significance are surveyed so that they can be included in the GCES-GIS system; and (2) to permit Indian people to better understand the role of GIS and the extant monitoring plan in protecting places and things potentially impacted by Glen Canyon water release. The survey trip will also allow monitors to test a potential monitoring form while in the field. This form will be developed based on the techniques and methods described in this preliminary chapter.

This effort will help put into effect Southern Paiute mitigation recommendations deriving from ethnographic field work presented in previous studies (Stoffle, Halmo, Evans and Austin 1994; Stoffle et al 1995). GCES surveyors will work with Southern Paiute representatives and UofA ethnographers to locate and survey known cultural resource locations. This effort will permit the concerns and recommendations that Southern Paiute people have for these resources to be included into the GCES-GIS system so that they can be monitored for potential impacts caused by the operation of the Glen Canyon Dam.

Survey Trip Itinerary (proposed)

Day #	Date	Camp Name	Mile #
01	7/05/95	North Canyon	20.0
02	7/06/95	Nankoweap	52.5
03	7/07/95	Cardenas Creek	71.0
04	7/08/95	Monument Canyon	93.5
05	7/09/95	Blacktail Canyon	120.0
06	7/10/95	Deer Creek	136.0
07	7/11/95	Matkatamiba	148.5
08	7/12/95	Cove Canyon	174.0
09	7/13/95	Parashant Wash	198.0
10	7/14/95	222 Mile Canyon	222.0

SOUTHERN PAIUTE CULTURAL RESOURCE MONITORING IN THE *COLORADO RIVER CORRIDOR*

The Glen Canyon Environmental Studies (GCES) has begun to consult with Native American groups in order to integrate their concerns into the long-range monitoring of cultural resources in the *Colorado River Corridor*. The Southern Paiute Consortium has already participated in an ethnographic inventory and assessment of archaeology sites, plants and rock art in the *Colorado River Corridor* (Stoffle, Halmo, Evans and Austin 1994). This research has provided invaluable information regarding the cultural perspective that Southern Paiute people have about their cultural resources, the Colorado River, and the Grand Canyon as a whole. The Southern Paiute tribal representatives that participated in these studies have expressed their concerns about the condition of specific cultural resources in the *Colorado River Corridor* and presented a series of recommendations to mitigate adverse impacts to these resources (Stoffle, Halmo, Evans and Austin 1994; Stoffle et al. 1995, Chapter Eight). The most prevalent recommendation was that all Southern Paiute cultural resources in the study area be protected from projects and programs that could have potential adverse impacts on them.

From the perspective of Southern Paiute people, *cultural resources* are intricate parts of larger culturally perceived geographic areas (see Stoffle et al. 1995, Chapter Four). For example, when Southern Paiute representatives were asked about the uses and significance of specific cultural resources in the *Colorado River Corridor*, they generally decided to talk about spatially large places rather than specific cultural resource *sites* (Stoffle, Halmo, Evans and Austin 1994). To Southern Paiute people, the resources in the *Colorado River Corridor* are simply one element of their *cultural landscape* in which humans, nature, and the supernatural are all integrated into a single whole. Consequently, Southern Paiute representatives seek protection of all elements of the cultural landscape, including plants, animals, water, and minerals, rather than of specific cultural resource sites. Attempts to monitor impacts to Southern Paiute cultural resources in the *Colorado River Corridor* must therefore document changes occurring to a number of elements of the cultural landscape.

Within U.S. federal law and for both state and federal land management agencies, the human and natural components of the landscape are "resources" to be "managed." Land managing agencies are governed by laws, regulations and guidelines associated with the scientific identification, evaluation, and management of "cultural resources". Therefore, the term *cultural resources* will be used to refer to elements of the Southern Paiute cultural landscape. Within the past few years, many land managing agencies in the U.S. have sought to increase consultation with Native American people about cultural resources within the land under their jurisdiction.

However, Native Americans are consequently put into a forced-choice decision process in order to single out specific "cultural resources" to protect rather than larger areas within which these resources are located. By considering the cultural concerns of the Southern Paiute people as well as the professional concerns of archaeologists and biologists, land managers can begin to effectively and comprehensively manage cultural resources in the *Colorado River Corridor*.

Changes occurring to cultural resources can be monitored by the use of field techniques or through the analysis of remotely sensed images. These methods are described in more detail below. The choice of monitoring techniques is dependent on the scale required to adequately understand change occurring to a particular cultural resource. Once a technique is chosen, changes to the condition of these cultural resources can then be recorded and entered into a Geographic Information System (GIS) database for management oriented analyses. A number of potentially useful GIS analyses are discussed below.

This report presents the reader with (1) a brief background of the Glen Canyon Environmental Studies-Geographic Information System (GCES-GIS), (2) one possible framework for developing a Southern Paiute cultural resource monitoring program, and (3) information about the development of a multimedia database of Southern Paiute cultural resources. The monitoring program is built around the concerns that Southern Paiute representatives have expressed about archaeological, botanical, and rock art sites in the *Colorado River Corridor* and their recommendations for protecting these resources (Stoffle, Halmo, Evans and Austin 1994). Continued consultation with Southern Paiute representatives may also yield additional areas of concern.

SOUTHERN PAIUTE RESOURCES AND THE GCES-GIS

Geographic Information Systems (GISs) are invaluable tools for measuring change over time because they allow diverse kinds of information about both the natural and human made environments to be managed and archived in one central database. A GIS is an organized collection of computer hardware, software, and geographic data designed to efficiently store, update, analyze, and display geographically referenced information (Dangermond 1991:11). GIS software performs a number of functions that are very useful for the long range monitoring of natural and cultural resources. These include overlaying different kinds of geographically referenced data, performing statistical and geographic correlations, creating buffers around geographic features such as cultural resources, and conducting spatial searches, change image analyses, and analytical modeling. One of the most useful features of a GIS is that it permits both cultural and natural resources to be managed on an ecosystem level. This management framework accords well with the cultural perspective of the Southern Paiute Consortium towards the *Colorado River Corridor*.

The concerns of American Indian people and other members of the public resulted in the development of the Glen Canyon Environmental Studies-Geographic Information System (GCES-GIS) database for long term monitoring of the impacts of variable flow rates from the Glen Canyon Dam. Long-term monitoring is defined here as "measuring the change over time in vegetation, geology, cultural resource areas, and habitat for rare and endangered species every 3 to 5 years" (GCES 1994:19). The GCES-GIS was designed to allow resource managers to monitor natural and cultural resources in the *Colorado River Corridor* and to serve as an archival database for information concerning the *Colorado River Corridor*. The Southern Paiute Consortium contributes to this monitoring process by identifying the location and size of areas of concern in the *Colorado River Corridor* and providing monitoring data about these areas to the GCES for integration into the GIS. Monitoring makes it possible for tribal representatives to determine the type and extent of impacts occurring to their cultural resources. By integrating monitoring data into the GCES-GIS, the Southern Paiute Consortium can also evaluate how these impacts are related to dam operations or management of the river system.

A GIS can produce both cartographic and tabular output regarding geographic features. Geographic features are simply elements of the physical landscape such as mountains or buttes. Cartographic data, which is stored in raster or vector formats, contains the topology or "anatomy" of geographic features. Information pertaining to these various geographic features, such as slope and soil type, is stored as attributes (also referred to as "characteristics of a geographic feature") in tabular computer files that are linked to the particular geographic feature.

Any type of cartographic or tabular data received by the GCES, including information about Southern Paiute cultural resources, must be converted into the GIS in a consistent geographically referenced format (GCES 1994). In other words, the geographic features that are identified in a given set of cartographic data, such as archaeology sites, must be accurately located on the planet earth relative to other geographic features, such as mountains or buttes. Geographic referencing of field surveyed data can be accomplished through conventional surveying techniques or the use of Global Positioning Systems (GPS). Georeferencing remotely sensed data is usually accomplished through the use of ground control points. GIS's make use of a number of geographic reference systems including longitude and latitude, Universal Transverse Mercator (UTM), and State Plane coordinates. Once a given data set is geographically referenced it can be imputed into the GIS for analyses in relation to other geographically referenced data sets. For example, changes occurring to archaeological sites, that are recorded as part of the monitoring program, can be analyzed in relation to erosion models, water flow, or levels of human traffic.

Data about geographic features such as cultural resources can be obtained from existing maps, field surveys, or from remotely sensed images. Monitoring data will partly be obtained through field surveys of geographically referenced cultural resource sites. However, the bulk of geographic information that is integrated into a GIS is usually acquired from remotely sensed images. Remote sensing is defined as the acquisition of information about an object or phenomena which is not in direct contact with the information gathering device. The bulk of remotely sensed images are obtained from photographic or multispectral sensors attached to airplanes or satellites. These images can provide the resource manager with a plethora of information about the natural and human made landscape. For example, topographic information about such geographic features as mountains and buttes can be gained from these images.

There are many sources and archives of remotely sensed images that are available to the public. Some of the most common sources are listed below.

(1) United States Geological Survey (USGS) EROS Data Center. This center is an archiver of all the Landsat imagery. This includes Multi-Spectral Scanner (MSS) images at 80 meter resolution per pixel and Thematic Mapper (TM) imagery at 30 meter resolution per pixel. The USGS also produces products called "Digital Elevation Models" (DEM) of both their 1 degree (approximately 100 meter resolution) and 7.5 minute (30 meter resolution) topographic quads. The Geographic Land Information System (GLIS), which is a subunit of the EROS Data Center, contains information about 38 sources of data regarding the Earth's land surfaces. There is a wide variety of digital images available from GLIS including land use/land cover digital cartographic files of the entire U.S. The EROS data center is located in Sioux Falls, South Dakota.

(2) The National Aerial Photography Program (NAPP). The NAPP is designed to acquire black and white or color infrared photography at a scale of 1:40,000 (1 inch on the map equals 40,000 inches on the ground). This data is available through the EROS data center or the Aerial Photography Field Office in Salt Lake City, Utah.

(3) SPOT Image Corporation. This company provides commercial access to imagery with 20 meter resolution per pixel that was acquired from the series of commercially developed SPOT satellites. The SPOT Image corporation is located in Reston, Virginia.

(4) Private Companies. There are a number of companies that will produce digital map images for users that do not have the technical expertise or resources to manipulate raw data into usable sources of information. Three of these companies are: (1) Environmental Research Institute of Michigan (ERIM) located in Ann Arbor, Michigan; (2) Environmental Sciences Information Center (ESIC) located in Tucson, Arizona; and (3) Positive Systems, Inc. based in Kalispell, Montana. These companies can also produce digital maps from aerial photographs they acquire themselves, although the cost is generally very high.

The Bureau of Reclamation's Remote Sensing Center in Denver, Colorado in cooperation with Horizons, Inc. has provided the GCES-GIS with a plethora of remotely sensed images of the *Colorado River Corridor*. Maps created from aerial photographs that have been geographically referenced and rectified (orthophotos) exist for the entire *Colorado River Corridor* in relation to the United States Geological Survey's 1:24,000 quad sheets (one inch on the map equals 24,000 inches on the ground). In addition, the entire river corridor of 291 miles was photographed with 1:2,400 color infrared (CIR) film for mapping natural resources.

Limited funds and time constraints prevents the GCES from monitoring the entire *Colorado River Corridor*. A GCES-GIS work group that included federal and state agency representatives, Native Americans, and members of other groups identified 15 sites that would be the focus of the long range monitoring plan, special studies, and the archive (see Appendix

A). These monitoring sites were selected because they represented the ecological diversity in the *Colorado River Corridor* or were areas of critical resources or where special studies have been done (Werth et al. 1993). Orthophoto maps at 1:2,400 scale were created for each of these 15 monitoring sites. These orthophotos contain cartographic data that cannot be obtained from the color infrared photos. The color infrared photos were then overlayed with the orthophotos to create hard copy maps (at 1:2,400 scale) for each of the 15 monitoring sites. These maps were digitized and transferred into the GIS so the data they contain could be analyzed in relation to other data sets. This dataset has a horizontal accuracy of 2.0 meters and vertical accuracy of 1.0 meter.

Other terrestrial, aquatic, and sediment data gained from either ground based surveys or other remotely sensed images is being collected and integrated into the GIS for each of these long range monitoring sites. In addition, more detailed types of data for specific large scale study areas is being obtained from field surveys. For example, botanical surveys have provided locational information about specific plant species within monitoring site number four (see Appendix A). These data have usually been acquired from members of the scientific community who have been doing research in the *Colorado River Corridor* and have provided the GCES with their data for incorporation into the GIS. Survey referenced data can produce digital data with sub-centimeter accuracy.

The GIS software used for the GCES-GIS database is ARC/INFO. This software runs on workstations using a UNIX operating system. The Southern Paiute Consortium, however, utilizes DOS based personal computers. This is not a serious problem because both cartographic and tabular data can be transferred into and out of the GCES-GIS in a number of UNIX or DOS based formats. The exact procedures that should be followed for transferring both tabular and cartographic data into and out of the GIS are outlined in the GCES's *Geographic Information System Information Guide and Operating Protocol* (GCES 1994). The Southern Paiute Consortium has been using *Lotus 1-2-3* for data storage and analysis and this program can also be utilized to code the Southern Paiute cultural resource monitoring data.

THE MONITORING PROCESS

The monitoring of cultural resources has not historically been an area of much research or concern among scientists or resource managers, largely due to lack of funds. Funding has tended to be funneled towards the acquisition of baseline data, such as Phase I surveys in the case of archaeological sites. Management of cultural resources like archaeology sites has occurred almost solely been through mitigation. Recently, as more extensive studies of cultural resources are conducted and incorporated into computer databases, there has been a consequent shift from mitigation to monitoring as a management strategy.

David Cole (1989) has developed a widely used sourcebook of monitoring methods. The monitoring system Cole describes provides a very useful outline for the development of a Southern Paiute Consortium cultural resource monitoring program. Cole's sourcebook is especially useful for the purposes of cultural resource monitoring in the *Colorado River Corridor* because it discusses issues involved in monitoring sites in remote wilderness areas. Monitoring cultural resources requires a clear conception of how the information acquired during the monitoring process will be used; data obtained from fieldwork and remote sensing will be used to document the changes occurring to Southern Paiute cultural resources in the *Colorado River Corridor*. Changes should be evaluated in light of the concerns and recommendations that the Southern Paiute Consortium has expressed about the landmarks and other elements of the cultural landscape in the *Colorado River Corridor*. If the impacts are severe enough to warrant action, certain procedures, which are discussed below, should be followed for dealing with these impacts. Data about the most important impacts should be transferred into the GCES-GIS for the purposes of spatial analysis and long-range monitoring. The monitoring process described in this chapter is divided into three steps, based on those described in Cole's sourcebook. These steps are outlined below and then are discussed in more detail in the following sections.

The first step in the development of a Southern Paiute Consortium monitoring program is choosing what cultural resources to monitor. This choice is guided by a number of factors including location and the concerns and recommendations of Southern Paiute people. After specific cultural resources have been chosen for monitoring, the second step is to determine for each resource the types of impacts to be monitored and the parameters used to measure these impacts. In this step, what actually will be monitored either in the field or through the use of remotely sensed images is determined.

The final step in developing a monitoring program is determining what methods best suit the kinds of impacts that are to be monitored. The choice of monitoring procedures is often limited by time and resource constraints. The monitoring system that is eventually adopted should tell the Southern Paiute Consortium as accurately as possible, for the most important parameters, the extent to which impacts have occurred (Cole 1989:2).

What Is To Be Monitored?

Effective resource monitoring begins with a systematic inventory of the kinds of resources to be monitored. This baseline data serves as the foundation upon which changes occurring to Southern Paiute cultural resources can be understood over time. It also serves as a starting point for deciding what resources to monitor. Existing inventories of four different types of cultural resources in the *Colorado River Corridor* are provided below. Once the available information has been assessed, a number of factors that may limit the particular cultural resources that can be monitored must also be considered. These factors are discussed below.

The geographic extent of the GCES's long-range monitoring program limits the choice of cultural resources that can be monitored. The GCES-GIS monitoring plan includes only those Southern Paiute cultural resources in the zone affected by the Glen Canyon Dam water release, which is defined as all riverine environments within the *Colorado River Corridor*. This zone includes the present beaches up to and including the farthest extent of the old high water zone marked by high dunes and mesquite.

In addition, there are a number of logistical factors that must also be considered when choosing which Southern Paiute cultural resources to monitor in the *Colorado River Corridor.* First, the proximity of one cultural resource to another must be considered. This is important because Southern Paiute Consortium monitors must make the most effective use of limited time and resources while in the field. Second, the Southern Paiute Consortium's field monitoring trips must be coordinated with the Grand Canyon National Park's (GCNP) scheduled archaeological monitoring trips. The stops that are planned on the GCNP's river trips will help guide the choice of Southern Paiute cultural resources that can be monitored. Ultimately, it is the concerns and recommendations that Southern Paiute people have expressed about each type of cultural resource that must be considered when choosing which resources to monitor.

Archaeology

A draft archaeological survey report entitled *The Grand Canyon Corridor Survey Project: Archaeological Survey Along the Colorado River Between Glen Canyon Dam and Separation Canyon* was produced by archaeologists at Northern Arizona University and Grand Canyon National Park in cooperation with the Glen Canyon Environmental Studies (Fairley et al. 1994). The site descriptions in this report include information on surface surveys, partial excavations, and artifactual and feature analyses. Out of the 475 total recorded archaeology sites in the *Colorado River Corridor*, 50 of these sites have been identified by archaeologists as either Paiute or Pai. As part of the ethnographic inventory and assessment of Southern Paiute cultural resources in the *Colorado River Corridor*, 36 of the sites identified as either Paiute or Pai in the archaeological survey were visited by Southern Paiute representatives (Stoffle, Halmo, Evans and Austin 1994).

In the GCNP's archaeological report, each site was recorded, mapped to scale and photographed. The GCNP staff utilized: (1) photographic documentation; (2) detailed and accurate maps of sites in relation to topography; (3) comprehensive assessment of site conditions and impacts; and (4) detailed information on the quantity, density, and variability of surface artifacts (Fairley et al. 1994:15). All site localities were plotted on both USGS 7.5 minute topographic maps and the GCES 1989 series of black and white aerial photographs. This data set has provided the basis for which changes occurring to archaeological sites can be monitored.

Limited time and resources prohibit the Southern Paiute Consortium from monitoring all the archaeological sites of concern to Southern Paiute people. It is therefore necessary to limit the number of sites that will be monitored. One possible solution is to limit the archaeology portion of the monitoring plan to either the 36 sites already visited by Southern Paiute representatives or to the 50 archaeological sites identified as Paiute or Pai by the archaeological survey. However, it is necessary to consider a number of other factors that reflect the concerns and recommendations of the Southern Paiute Consortium.

The Southern Paiute representatives singled out a number of archaeology sites to receive special monitoring attention. Access to all five of these sites should be severely restricted. They include the "womans healing" site at Bedrock Canyon [AZ:B:11:282-Stop #22, near Mile 209] and four sites at Granite Park [AZ:G:3:26, AZ:G:3:27, AZ:G:3:28, AZ:G:3:3-Stop #22, near Mile 209].

Another important consideration when choosing archaeology sites to monitor is their proximity to other resources of concern to Southern Paiute people. Research has indicated that Southern Paiute people perceive sites as consisting of more than just archaeological materials and other remains (Stoffle, Halmo, Evans and Austin 1994:193). Their broader perceptions of an archaeology site include natural resources such as plants, animals, and water in a larger spatial area than the more narrowly bounded "site" in archaeological terms. One way of assuring that this holistic view of cultural resources is taken into account is to monitor a number of cultural resources that are in close proximity to each other, like archaeological sites and culturally significant plants, as part of one monitoring site.

The types of features found at archaeology sites (as identified by Stoffle, Halmo, Evans and Austin 1994:194 and Fairley et al. 1994:23-24) might also serve as a possible way of prioritizing what sites to monitor. In the future, if the cultural significance of specific features of archaeology sites can be determined with some level of accuracy, then the cultural significance of sites not visited might also be able to be determined.

There are a number of other factors that should also be considered before choosing archaeology sites to monitor. These are listed below by level of importance.

(1) *Proximity to Water.* Archaeology sites closest to the water might be the most seriously affected by water release and therefore might require special monitoring attention. This factor cannot be considered until accurate measurements of proximity for each site are obtained (see **Monitoring Methods** below).

(2) *Type of Site.* The GCNP archaeology report identified 25 different types of archaeological sites in the Grand Canyon (Fairley et al. 1994:21-22). These can serve as a possible source of prioritizing sites to monitor. For example, should burials receive special considerations when choosing monitoring sites? The degree of cultural significance that is assigned to a particular type of archaeology site might also help to prioritize which sites to monitor. However, the vast majority of Southern Paiute representatives who participated in the ethnographic field trips believed that all the archaeology sites they visited were highly significant. This result is inconclusive because there is at this time no refined technique for calculating cultural significance for either archaeology sites or rock art panels and sites.

(3) *Function of Site.* Southern Paiute representatives have identified five principal uses for archaeology sites. These include farming, hunting/camping, ritual/ceremony, gathering foods, and trade (Stoffle, Halmo, Evans and Austin 1994:174).

The GCNP began to monitor archaeological sites on a yearly basis in 1991. Consequently, the GCNP already has data from which they can prioritize the choice of sites to monitor. The four main factors used by the GCNP when choosing the priority of archaeological sites to be monitored include (Coder, Leap, Andrews and Hubbard 1994):

* present levels of natural impacts
* accessibility to the public
* degree of risk based on setting and proximity to the river
* current condition of each site

These factors are almost identical to the concerns that Southern Paiute people have expressed about their cultural resources in the *Colorado River Corridor*. The Southern Paiute Consortium will therefore have to do additional monitoring of archaeology sites if two conditions are *not* met. First, does the list of archaeology sites monitored by the GCNP include all the sites of concern to the Southern Paiute Consortium? Second, are the parameters used by the GCNP to measure impacts to archaeology sites acceptable to the Southern Paiute Consortium (see Appendix B)?

Plants

Around 1400 species of plants have been identified in the Grand Canyon (Phillips, Phillips, and Bernzott 1987). The ethnobotanical study of Southern Paiute plants (Stoffle, Halmo, Evans and Austin 1994) identified 205 plants at 21 sites in the *Colorado River Corridor*. Out of these 205 plants, 68 species of plants were identified as culturally significant by the Southern Paiute participants. Although Southern Paiute people would prefer that all plants in the *Colorado River Corridor* be preserved, it is those plants that have been identified as culturally significant that are the priority for monitoring. If a particular culturally significant species of plant cannot be protected, the same plant species must be preserved at another location. Areas where the same plants exist can be possibly identified through the use of the GCES-GIS. This type of analysis depends on the detail of information available to the GIS. In order to identify areas where specific species of plants exist, that information must be available as a georeferenced dataset in the GIS. At this time, only groups and not specific species of vegetation associated with the old and new high water zones have been integrated into the GIS for the 15 monitoring sites (see Werth et al 1993:39).

The Southern Paiute representatives expressed special concerns about an ancient Goodings willow at Granite Park. This specific tree should be given special monitoring consideration. Other important factors when considering which plants to monitor are listed below.

(1) *Proximity to Water*. Fluctuating river levels are perceived to be causing the uprooting of plants. The loss of native plants is viewed by the Southern Paiute representatives as more damaging than the potential loss of archaeology sites in the sand banks. This factor cannot be considered until accurate measurements of proximity for culturally significant plants are obtained (see **Monitoring Methods** below).

(2) *Degree of Cultural Significance*. Both the Index of Cultural Significance (ICS) and Ecozone Significance (ES) scores (taken from Stoffle, Halmo, Evans and Austin 1994:270, 277) should be taken into account when choosing plants to monitor. Since the new and old riparian zones had the highest ES scores, plants in these ecozones have the highest monitoring priority. However, the Southern Paiute Consortium should also consider whether they would like to monitor plants that represent a range of ecozones rather than plants from ecozones that have the highest ES scores.

Rock Art

Twenty-three rock art sites have been visited by Southern Paiute representatives in the *Colorado River Corridor* (see Stoffle et al. 1995, Chapter Five). All of these culturally significant resources should be monitored if possible. However, the rock art site at Nine Mile Draw [Site #C:02:038] was damaged over the summer of 1994 and has been noted as an ARPA violation (see Figure 1.1). This site should receive special monitoring attention.

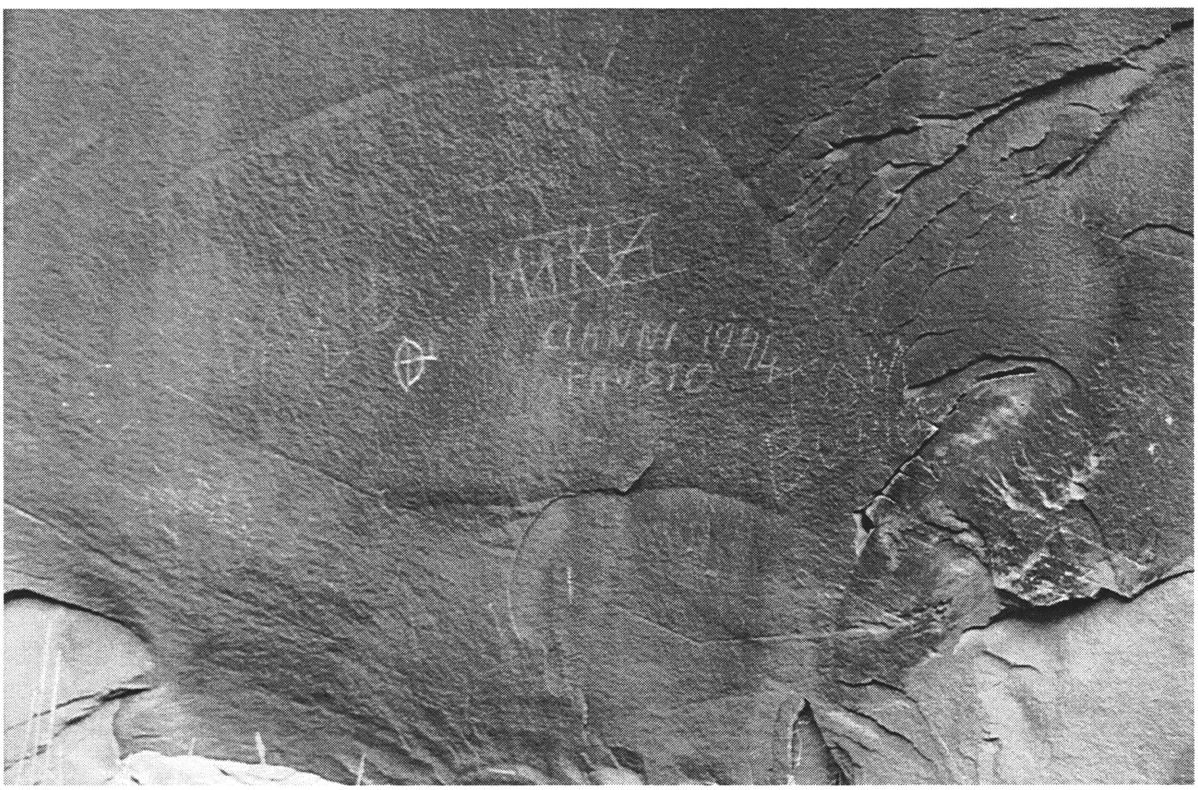

Figure 1.1. Vandalism at Ninemile Draw petroglyph site. Note the recent addition in 1994.

Traditional Cultural Properties

Southern Paiute representatives also expressed concerns over a number of traditional cultural properties (TCP) located in the *Colorado River Corridor.* TCPs are places that have special religious, sacred, or historical significance to Southern Paiute people (Parker and King 1990:1; Stoffle et al. 1995, Chapter Seven). These are sites that are particularly sensitive to Southern Paiute people. Visits to the following sites should therefore be restricted and receive special monitoring attention.

(1) *Ompi* (Hematite) Cave
(2) Salt Cave
(3) Deer Creek Valley and Falls
(4) Vulcan's Anvil
(5) Granite Park
(6) Pumpkin Spring

Animals

Although systematic ethnofaunal studies have not been conducted in the *Colorado River Corridor,* animals have considerable cultural and religious significance to Southern Paiute people. Birds, such as eagles, are perceived as important and are prayed to and talked with when captured. The desert tortoise, which is part of Southern Paiute religious symbolism, and the chuckawalla, which is used medicinally, have been singled out in previous studies (see Stoffle, Halmo, Olmstead and Evans 1990) as being important to Paiute people. These animals can be considered as cultural resources when they are perceived from the cultural and religious perspective of Southern Paiute people. Future monitoring plans should include Southern Paiute ethnofaunal resources.

Impact Parameters

Once specific cultural resources are chosen to be monitored, the kinds of impacts that are of concern to Southern Paiute people must be identified. In order to accurately measure changes occurring to Southern Paiute cultural resources, a number of discrete parameters must be developed that clearly identify both the degree and types of impacts that could occur. These impact parameters are determined by the goal and function of the monitoring plan and by the level of change that is needed to be understood. Each type of cultural resource could therefore contain a number of impact parameters that can be used to assess the condition of an entire site. The change occurring to each impact parameter, as well as to the summary impact ratings for an entire site, will serve as an index of the condition of Southern Paiute cultural resources in the *Colorado River Corridor.* The integration of monitoring data, which is acquired by measuring changes to these impact parameters, into the GCES-GIS's long range monitoring effort allows Southern Paiute concerns to be considered in the management of this important area.

Southern Paiute cultural resources in the *Colorado River Corridor* are potentially impacted by either natural processes or human activities. These are perceived very differently by Southern Paiute people (see Stoffle et al. 1995, Chapter Eight), so the monitoring form that is eventually adopted by the Southern Paiute Consortium should separate the kinds of impacts to be monitored according to their source. Identifying the source of impacts occurring to Southern Paiute cultural resources is also essential for mitigating present impacts and preventing future ones.

Natural impacts include the effects of biotic, hydrologic, and geologic processes on cultural resources. Erosion is the most significant natural factor impacting cultural resources in the *Colorado River Corridor*. The primary cause of the ongoing erosional problem is the restricted flow of water through the Glen Canyon Dam (Coder, Leap, Andrews and Hubbard 1994). Human impacts include the affects that the activities of people can have on cultural resources. For example, tourists visiting archaeological sites in the Grand Canyon often collect surface artifacts like pottery sherds into piles alongside the site (see Figure 1.2).

Figure 1.2. Example of a collector's pile, a common sight at archaeological sites in the *Colorado River Corridor*

The construction and continued operation of Glen Canyon Dam has altered the pattern of natural processes in the *Colorado River Corridor*. Determining the root cause of impacts is therefore difficult. Many natural processes like surface erosion or bank slumpage are actually caused by human activity. Differentiating between human and natural impacts should be an area of concern in the monitoring program. Many perceived "natural" impacts like erosion are in fact caused by the continued operation of the dam. Although Southern Paiute people would prefer that all their cultural resources be left alone, if the resource in question is endangered or unique their recommendations might include transplantation or building a ditch around the site to prevent erosion (see Stoffle et al. 1995, Chapter Eight).

General Concerns for Cultural Resources

The Southern Paiute Consortium has expressed the desire that all their cultural resources in the *Colorado River Corridor* be preserved as they are, not removed or modified in any way (Stoffle, Halmo, Evans and Austin 1994). This reflects the Southern Paiute people's general preservation philosophy about their traditional lands and the animals, plants, artifacts, burials, and minerals that exist within these lands. In other words, Southern Paiute cultural resources should be *left in place* and access to them *should be restricted.* The list below provides a basis for determining what kinds of impacts should be measured.

* Assess condition of cultural resources
* Identify cultural resources potentially impacted by erosion and other natural processes in order to reduce erosion affecting these resources.
* Monitor disturbance from human visitation
* Monitor effects from water flow
* Monitor effects from erosion and other natural processes

The change that is recorded for each impact parameter, as well as the summary impact ratings for an entire indicator resource, will serve as an index of the condition of Southern Paiute cultural resources in the *Colorado River Corridor*. Potential impact parameters for each type of cultural resource are mentioned below. Summary ratings can be gained by summing a series of ordinal rankings, essentially the sum of all the measured impact parameters, or by creating a separate condition class for an entire site. Acceptable levels of impacts occurring to each parameter and to summary ratings must be determined by the Southern Paiute Consortium. These levels of acceptability will help to determine when actions must be taken to prevent or mitigate adverse impacts.

Archaeology

There are a variety of natural impacts identified on the existing Grand Canyon National Park (GCNP) archaeology monitoring form that could potentially change the condition of an archaeological site. These impacts include *surface erosion (0-10cm)*, *gullying(10-100cm)*, *arroyo cutting(>1m)*, *bank slumpage*, *eolian(wind)/alluvial(water) erosion or deposition*, *side canyon erosion*, *animal-caused erosion (trailing, burrowing)*, and *other natural impacts (spalling and roots)* (see Appendix B).

Many archaeological sites are in and above the Old High Water Zone (OHWZ), and the Southern Paiute representatives perceive that these are primarily impacted by tourists. Human impacts can include *inundation*, *trampling*, *trailing*, *collection piles*, *vandalism*, *trash piles*, or *on-site camping*. All of these impacts are already included in the GCNP's archaeology monitoring form. The Southern Paiute monitoring form should also include extra space for recording other kinds of human impacts not covered by those mentioned here. Southern Paiute representatives also expressed concerns about the *accessibility* of archaeological sites. The more accessible an archaeology site is to tourists the more likely it is perceived to have adverse impacts.

The GCNP's FY93 archaeological monitoring report concluded that the degree of human impact varies according to the time of year (Coder, Leap, Andrews and Hubbard 1994:1). During the late summer and early fall sites exhibited more impacts from visitation. These human impacts included trailing, trampling, and trash. On the other hand, in February and March sites exhibited less human impact because they had the late fall and winter to recuperate. When deciding on what time of year to monitor, the Southern Paiute Consortium should take these conclusions into consideration.

Trailing remains the most frequent human impact observed by the GCNP and has the "greatest potential for long-term damage to cultural properties" (Coder, Leap, Andrews and Hubbard 1994:4). Accelerated erosion throughout the *Colorado River Corridor* has caused the subsequent incremental loss of archaeological sites (Coder, Leap, Andrews and Hubbard 1994). Archaeological sites in sand banks between the river's edge and old high water mark are the most seriously affected by erosion. A number of elders expressed the belief that it is appropriate for the things of the old people, such as archaeological sites, to naturally decay *in situ*. The monitoring of archaeological sites might therefore concentrate on human impacts rather than natural ones.

Plants

The loss of native plants is viewed by the Southern Paiute representatives as more damaging than the potential loss of archaeological sites in the sand banks. Fluctuating river levels are perceived to be causing the *uprooting* of plants, which is the most serious natural impact to be considered. Southern Paiute representatives perceived that the primary human impacts occurring to culturally significant plants were *trampling*, *clearing* and *picking*. *Accessibility* by tourists to areas where Paiute plants grow was an additional area of concern. Overall, the *health* of native plants was also an area of major concern.

Rock Art

Although there are numerous natural and human impacts that could potentially affect rock art sites, a number of the most significant have been identified here. Natural impacts include *surface water (direct water erosion, mineral accretion, and frost damage)*, *salt deterioration*, *soil cover*, *vegetation*, *microflora*, and *animals* (Lambert 1989). The number of visits to rock art sites in the *Colorado River Corridor* serves as an index to the potential human impacts occurring at these sites. Potential human impacts include *vandalism*, *graffiti*, *dust cover caused by foot traffic*, and *erosion caused by trailing*. For example, at Nine Mile Draw, erosion was increased at the base of the rock art panel because of trailing (see Figure 1.3). This is also an example of where a "natural" impact has a human source. Factors affecting the level of potential human impacts include *accessibility* and *visibility*; these were areas of concern expressed by the Southern Paiute representatives that affect the amount of visitation.

Figure 1.3. Compaction and erosion resulting from people walking near the rock art panel.

Traditional Cultural Properties

The potential impacts that could occur to TCPs depend on the nature of the resource. Some TCPs are also archaeological sites. The methods used to monitor these places would be the same as the procedures used for archaeological sites. On the other hand, a landmark like Vulcan's Anvil is a geological feature and consequently requires different procedures for monitoring. The potential impacts occurring to Vulcan's Anvil are much the same as the natural impacts potentially impacting rock art panels and sites. The condition of large areas like Granite Park can be evaluated by looking at changes occurring to a number of different cultural resources. In this case, an additional analysis of ecosystem health might also prove to be useful.

Animals

Once the data acquired on the ethnofaunal trip is analyzed, the concerns and recommendations that the Southern Paiute Consortium has about animals in the Grand Canyon can be integrated into the monitoring plan. These concerns and recommendation will, in turn, be transformed into discrete impact parameters that can be measured to understand the changes occurring to animals in the *Colorado River Corridor.*

Monitoring Methods

Providing the reader with a variety of methods for monitoring Southern Paiute cultural resources in the *Colorado River Corridor* constitutes one of the primary goals of this chapter. However, the ways in which cultural resources are monitored reflect the concerns of those involved in their management. The concerns that Southern Paiute people have for their cultural resources are not necessarily the same as archaeologists and other scientific professionals who are put in charge of managing these resources. Alterations to Southern Paiute cultural resources are not only manifested in physical ways but also in cultural ones. For example, changes to cultural resources are perceived by Southern Paiute people as relating to changes occurring to other cultural landmarks, to the ecozone, and ultimately to the Grand Canyon itself. Yet, methods for documenting and monitoring cultural and natural resources that have been developed by scientific professionals can serve as a foundation by which these "cultural impacts" can also be monitored.

There are two primary ways in which changes occurring to Southern Paiute cultural resources in the *Colorado River Corridor* can be measured. These include the use of field techniques and the analysis of remotely sensed images. When considering these techniques, available time and resources must be taken into account. Whatever monitoring procedures are eventually chosen by the Southern Paiute Consortium they must also be sufficiently detailed to permit the evaluation of changes in site conditions over time.

A number of field techniques have been developed by Cole (1989). These include (1) photographic documentation from permanent camera points; (2) condition class estimates; (3) permanent measures; and (4) nonpermanent measures. These techniques can be used to monitor all four of the type of cultural resources described here. The issues involved in photographic documentation are covered below in the sub-section entitled *Rock Art*. Only the last three techniques are described here. These three techniques require the development of a field monitoring form. The GCNP form for monitoring archaeological sites is provided in Appendix B. However, if at all possible, data should be entered directly into a computer while in the field. This is a labor saving technique because it avoids the later step of data entry and also reduces potential errors that are introduced as data are transferred from paper forms to a computer database.

Condition class estimates are based on defined levels and/or types of impacts. When using this technique, the presence, absence, or degree of change in certain critical parameters can be quickly noted to form the basis for an impact rating (Cole 1989:4). A given cultural resource is assigned to a class that most accurately describes its condition. These classes should be exclusionary. New parameters can be added as situations arise. This technique allows a monitor to summarize the condition of an entire cultural landmark. The estimated time required at each cultural landmark would be three to five minutes. *Nonpermanent measures* are similar to condition class estimates except that each individual impact parameter is recorded separately. This technique allows a large amount of information to be gathered in a short amount of time (10-15 minutes per cultural landmark).

The major problems with these methods are (1) uncertain measurement errors, and (2) the inappropriateness of condition classes that arises because they sum a series of ordinal rankings. Measurement errors can be reduced if monitors are given step by step descriptions of how each impact parameter should be evaluated. Each impact parameter should therefore be given a precise definition so there is little room for error. These impact parameters should also be tested in the field before they are used in an actual monitoring program.

Permanent measures are detailed measurements of a number of impact parameters on permanently located sampling units, usually quadrants, transects, or the entire site. These techniques usually take one to three hours per cultural landmark. However, these methods provide a high degree of accuracy and a wealth of information about changes occurring to cultural resources. A number of permanent and rapid monitoring methods are described by Cole (1989:36-57) and two examples are included in Appendix C of this report. Detailed measurements can be obtained on a sample of sites to supplement less precise rapid estimates taken on all sites. Methods for quadrant and transect operation can be found in an article by William Degenhardt (1966).

The other main method for monitoring change to Southern Paiute cultural resources is through the analysis of remotely sensed images. One way of measuring *accessibility* is by identifying the presence of paths to a given Southern Paiute cultural resource site and how they change over time. By analyzing changes to aerial photos or satellite images taken over a period of time, alterations to the size and length of trails can be determined. The presence of trails in the *Colorado River Corridor* is also highly correlated with the presence of camp sites, which are in turn often associated with the location of beaches. Fluctuating river levels caused by the operation of Glen Canyon Dam affect the level of bank slumpage, which may potentially alter patterns of beach/camp usage. If the level of human traffic was known at each camp in the *Colorado River Corridor*, this information could then be correlated with the levels and types of impacts occurring at Southern Paiute cultural resource sites.

Once the geographically referenced location of a cultural resource site, such as a rock art panel, is entered into the GIS, the *visibility* of such a site can be determined through viewshed analyses. These analyses can highlight areas that might require special monitoring attention. Aerial photographs can also be used to determine changes occurring to vegetation (Pucherelli 1988;Waring 1994), although identifying changes to particular species of plants requires the use of ground based surveys. Once the Southern Paiute Consortium provides the GCES-GIS with accurate georeferenced information about their cultural resources in the

Colorado River Corridor, these resources can be analyzed in relation to other elements of the GIS such as water flow, erosion, and human traffic.

The scale and resolution of the images that are needed is dependent on what exactly is being monitored and the scale of change the monitor needs to understand. For example, if we want to understand change to an individual tree, a satellite image at 30 meter resolution per pixel is not sufficient enough to decipher changes occurring to this specific tree. On the other hand, if we want to understand changes to an entire plant community or vegetation as a whole than this type of satellite image might be sufficient.

Archaeology

While in the field, there are many ways to assess the condition of an archaeological site. One way is through the comparison of surface surveys of a pre-defined site area. Another method is to monitor change occurring to key artifacts identified by Southern Paiute representatives. Other focuses of archaeological monitoring can include changes to artifact density and site area (Fairley et al. 1994:24). Monitoring changes to one or many elements of an archaeology site can be accomplished in two main ways: through the use of quadrants or transects (permanent measures) and through the use of pre-determined condition classes (non-permanent measures). Quadrants and transects are ideal for gaining accurate estimates of changes occurring to artifact quantity, density, and movement. Condition classes can measure these same type of changes with significantly less accuracy. However, condition class estimates can also be used to identify and measure changes that are less quantifiable and more perceptual in nature.

Both the level and type of natural and human impacts occurring to archaeology sites can be monitored by using photography, through pre-defined condition classes measured by on-site observations, or through the analysis of remotely sensed images. Photography has already proven to be a very useful and efficient method of documenting changes occurring to archaeology sites (see below). Condition class estimates will provide the bulk of data acquired by Southern Paiute monitors. The Grand Canyon National Park's archaeology monitoring form already includes a number of condition classes for measuring the affects of natural processes and human activities on archaeology sites in the *Colorado River Corridor* (see Appendix B). If the georeferenced locations of archaeology sites are known, then the susceptibility of these sites to increased water flows, erosion, and human traffic (paths and camps) can be assessed using remotely sensed images. However, proximity to water, the degree of erosion ,and level of human traffic occurring at a particular archaeology site can also be measured by on-site observations. Ultimately, a combination of these methods might provide the most accurate monitoring data, given limited time and resources.

The archaeological staff at the GCNP have developed a form to monitor natural and human impacts on a select number of archaeological sites throughout the *Colorado River Corridor* within the GCNP (see Appendix B). While in the field, the monitoring crew also takes black and white photographs of selected features, examples of erosion, and specific areas of sites at risk. These photos are duplicated each field trip. Black and white photographs are used instead of color for archival purposes. The GCNP has collected over 3800 black and white images which serve as one of the most important sources of visual information illustrating change for cultural properties and geomorphic processes in the Grand Canyon (Coder, Leap, Andrews and Hubbard 1994:2). In addition, there are five stationary cameras recording a single color image every day. In practice, these cameras have generated thousands of nearly identical images. These color images are stored at Northern Arizona University as part of a beach erosion study.

Archaeological monitoring reports are reproduced by the GCNP on a yearly basis. In Fiscal Year 1993 (FY93), 137 separate archaeological sites were monitored (Coder, Leap, Andrews and Hubbard 1994) out of 475 sites that had been surveyed in 1991 (see Fairley et al. 1994:16-38). The FY93 report included a number of suggestions for future monitoring. The monitoring crew believed that detailed mapping using a total station was warranted for important sites. They also recommended that units tracking artifact movement on the surface be established at all monitoring sites. Two other areas that they believed should receive special attention included the quantification of geomorphic change and the stabilization of erosion. The GCES-GIS crew has been hard at work in developing models of geomorphic change of the 15 monitoring areas they have selected for study (Werth et al. 1993). The stabilization of erosion could possibly conflict with the concerns of the majority of Paiute representatives, who recommended that preservation of cultural resources sites be accomplished without altering the site itself.

Plants

Either individual stands of plants (one species) or plant communities (many species) can be the object of monitoring. Individual stands of plants should be primarily monitored by on-site observations. If a stand of plants or plant community is small (under 2 meters), measuring change through the analysis of remotely sensed images becomes very difficult. Large plant communities, however, can be monitored both in the field and through the analysis of remotely sensed images. In addition, impacts occurring to entire ecosystems can also be monitored as a method for incorporating the holistic concerns that Southern Paiute people have about the Grand Canyon.

Changes occurring to vegetation have been documented in a number of ways. One of the most effective ways of assessing changes occurring to plants is through the use of photography (see Hastings and Turner 1965; Rogers 1982; Turner 1980). Methodological considerations in using photography for monitoring purposes are discussed in the *Rock Art* section below. Changes occurring to plant communities, plant stands, and even individual plants (such as the Goodings willow at Granite Park) can also be monitored through the use of remotely sensed images. Luckily, the GCES has produced a series of high resolution maps (at 1:2,400 scale) for the 15 monitoring sites. Pucherelli (1988) has used aerial photographs to track changes in vegetation cover in both the Old and New High Water Zones. His research indicates a significant increase in vegetation cover in the New High Water Zone from 1965 to 1980 and a significant decrease in cover after the flood in 1983. A recent study (Waring 1994) has evaluated current and historical riparian vegetation trends in the Grand Canyon using multitemporal remote sensing images at the 15 long range monitoring sites. However, both photography and remote sensing serve mainly to complement measurements made in the field using permanent or condition-class methods (see **Monitoring Methods** above).

In order to monitor plants for potential uprooting, their proximity to water (i.e. the Colorado River) and susceptibility to potential or existing erosion must be identified. Within the 15 monitoring sites, the proximity of plants to water and areas of erosion can be measured by analyzing the spatial location of plants in relation to fluctuating river levels and erosion models. Images that display the level of the Colorado River in relation to the riparian environment, have already been developed by the GCES-GIS and are updated on a regular basis. Erosion models for the *Colorado River Corridor* are being developed using remotely sensed images and field surveys. Similar erosion models were developed for Petroglyph National Monument in order to asses potential erosion occurring to petroglyph and paleontological sites (Phil Guertin, personal communication, 1994). These type of analyses can be used to identify possible or existing areas of uprooting from fluctuating water levels or erosion. Remotely sensed images can also be used to monitor the accessibility of culturally significant plants when analyzed in relation to maps of paths and map sites. Culturally significant plants that are identified to be in one of these susceptible areas can be given priority for monitoring purposes.

Remotely sensed images can be used to not only monitor changes occurring to areas where culturally significant plants have already been identified, but also to identify other areas in the *Colorado River Corridor* with the same plants species or community. However, one of the biggest difficulties in using remote sensing to monitor plants is the inability to differentiate between species. Some plants live in a community with other plants, while some live spatially separated from other species of plants. Both the identification and analysis of small plant stands or communities must be ground-truthed by on-site observations.

Southern Paiute representatives have expressed concerns that human activities in the *Colorado River Corridor* are causing the trampling, clearing, and picking of culturally significant vegetation. Trampling, clearing, and picking are most accurately monitored through the use of quadrants and transects in permanently placed monitoring sites. These permanent measures can be used in conjunction with condition class estimates, which rely on visually identified assessments of less well defined sampling units, to estimate the amount of human impact that has occurred. By using a combination of permanent measures (quadrants and transects) and condition class estimates to measure changes occurring to vegetation in the *Colorado River Corridor*, Southern Paiute monitors will increase the accuracy and reliability of their measurements. Choosing where to place the quadrants or transects must take some considerable forethought. Permanent measures like these could be used to measure changes occurring to the most important plant stands and communities, to plant communities that are indicators of ecosystem health, and to plants that reflect either the most important or the largest range of ecozones. The sites that are eventually chosen for plant monitoring must include all 68 culturally significant plants and possibly more if the Southern Paiute Consortium deems this necessary.

Trampling, picking and clearing can cause changes in soil conditions and in vegetation growth (Sun and Liddle 1993:497). These type of human activities can specifically cause a reduction in: species composition (diversity), species number (abundance), plant biomass, and plant height. When monitoring plants for impacts from human activities, Sun and Liddle (1993) measure the number of species present, the amount of soil penetration resistance, visually estimate the total number of all the plants and number of each individual species (abundance), and vegetation height. They created four classes of sampling units from these measurements. These classes included: untrampled areas, slightly trampled, moderately trampled and heavily trampled. All four classes were characterized during initial survey trips and were used to determine rates and levels of change occurring to vegetation. According to Cole (1987), soil compaction can be used as a surrogate measure of trampling intensity. Cole used a soil penetrometer to measure soil bulk density and soil penetration resistance, which were surrogate measures of the degree of wear happening to plants because of trampling. These instruments are easy and quick to use (see Liddle 1973).

Cole (1992:256) has developed a useful and simple method to determine areas of vegetation loss on wilderness campsites. The most significant impacts included in his study are those caused by trampling (human impact), disruption of organic soil horizons (natural impact-erosion) and compaction of mineral soils (human impact). However, Cole looks solely at the impact of trampling on area of vegetation loss. The absolute vegetation loss is calculated by subtracting the mean vegetation cover on the sampling unit from the mean cover on a comparable undisturbed sampling unit. The actual area of vegetation removed is calculated by multiplying the absolute vegetation by the area of the sampling unit. Erosion can be monitored through the use of photography, condition-class estimates, or through the analysis of remotely sensed images. The amount of soil compaction resulting from human activity can be measured using a soil penetrometer. The data that is acquired from this instrument can be used as a surrogate measure of trampling intensity (see Cole 1987). Cole also examined the influence that three independent variables had on the area of vegetation loss. These variables include: (1) amount of use; (2) vegetation fragility; and (3) the degree to which on-site traffic is concentrated. Monitoring data can be correlated with data concerning amount of use and the degree to which on-site traffic is concentrated to determine correlations concerning the source of human impacts. Data regarding vegetation fragility can also be used to determine the differential susceptibility of the plants being monitored.

Ecosystem Monitoring

Ecologists studying the flora and fauna of the *Colorado River Corridor* have correctly identified the close interrelationships between the aquatic and riparian ecosystems of the Grand Canyon. For example, the riparian ecosystem in the Grand Canyon is extremely important to the nesting avifauna of the lowland Southwest and other wildlife in the region. In fact, the construction of Glen Canyon Dam has caused an increase rather than a decrease in riparian vegetation and associated animal populations in the Grand Canyon. One prominent example is the increase of nesting bald eagles at Nankoweap.

However, scientists do not necessarily perceive ecological interrelationships in a cultural manner, nor are they necessarily concerned about ecosystems in a cultural way. On the other hand, the Southern Paiute people are indigenous to the area known as the Grand Canyon and perceive it as an integral part of their cultural landscape (see Stoffle et al. 1995, Chapter Four). Their concern for plants reflect a concern for the Grand Canyon as a whole. Not surprisingly, any specific attempt to monitor culturally significant vegetation in the Grand Canyon must be related to other elements of their cultural landscape such as animals and sacred sites. One possible way of incorporating this holistic concern for the Grand Canyon into the monitoring program is by looking at changes occurring at the ecosystem level. Scientists monitor the "health" of ecosystems primarily by looking at biological diversity.

Over the last 30 years, biological diversity has become a primary area of concern in natural resource and wildlife management. For many years, the scientific community measured the productivity of ecosystems by the amount of biomass they produced. Biomass is literally the weight of biological material produced in a given area. Recent studies have indicated, however, that biological diversity plays a significant role in the stability and adaptability of biological systems (Norton 1987). Biological diversity can be measured at the genetic, species, community (ecosystem) and regional (landscape) levels. However, it is species richness that is mentioned the most in relation to the management of biological diversity. Species richness refers to the number of species encountered in a particular area. This is the strictest definition of diversity because it does not include any other index other than shear number of species.

Plants that are part of riparian environments serve as both indicators and processors of environmental conditions. Riparian plants respond to changes in temperature, soil, moisture, slope, aspect and even human activity that are affecting specific places (Johnson 1991:181). In addition, vegetation consists of the principle autotrophs upon which most other organisms depend (Whitaker 1975). In other words, the health of a plant community is an indicator of the health of most of the other elements of an ecosystem. Not surprisingly, some scientists have suggested that plant community diversity provides an efficient single measure of overall biological diversity (Lesica 1993:70). However, Lesica indicates that this might exclude some habitats that are poor in plant species. Within a given ecozone, plant species richness can be used in either addition to or to substitute for plant community diversity.

A project to monitor natural resources at Channel Islands National Park focused on species population dynamics. This included abundance, distribution, age structure, reproduction rates, phenologies, etc. By gathering this type of data, the monitors were able to understand how and why populations of plants and animals fluctuate and what factors influence their survival or demise. Although such a system provides a wealth of information about changes occurring at the species level, it does not provide a holistic understanding of changes occurring at the ecosystem or regional level.

Lesica (1993; see also Magurran 1988) used Shannon's Index of Diversity to measure community diversity because it takes both species richness and evenness into account. Species evenness refers to the distribution of species within a given area. Shannon's Index of Diversity can be utilized to measure either plant species or community diversity. If plant communities were to be used to measure changes occurring both to the plants themselves and the ecosystem as a whole, then the plant communities in the Grand Canyon must be identified. Once plant communities are characterized they are easier to identify than individual species of plants and require less time in the field.

Payne and Bryant (1994:7) have created a list of required information to assess changes in biodiversity. These include: (1) assessing the processes and patterns of presettlement vegetation; (2) inventorying the ages classes of trees and/or community diversity; (3) analyzing the existing extent of corridors connecting communities; (4) assessing various guild or indicator species; (5) determining the minimum viable populations, distribution, and desirable population level; and (6) quantifying habitat parameters. Guild species are those species from a group of species that share a need for common resources in the environment (Payne and Bryant 1994:6). Indicator species are those species with an ecological tolerance so narrow that its abundance indicates certain environmental conditions (1994:6). Other considerations for managing biodiversity include: assessing successional changes due to natural or human caused changes to the ecosystem, assessing potential ecosystem health indicators such as plant community diversity, and developing procedures for habitat monitoring at one of the four levels of biological organization (genetic, species, ecosystem, regional).

In order to understand how certain plants species and/or communities are changing over time, there must be a conception of what they are like now. Initial surveys must accumulate baseline data about vegetation in the *Colorado River Corridor* in order to assess the existing condition of cultural significant plants. For the purposes of controlled comparisons, the Southern Paiute Consortium might also want to develop an "ideal site" that represents the vegetation under perfect conditions.

Rock Art

A series of procedures for recording rock art have been developed for Petroglyph National Monument that are applicable to other rock art sites and settings (Walt and Brayer 1994:48-50). General field methods for recording rock art have also been developed for the National Park Service as a whole (Loendorf, Olson and Conner 1993). Both reports outline a number of procedures for developing field survey forms, survey methods, and methods for mapping, photographing, drawing, rubbing, and tracing rock art for the purposes of documentation. The management and preservation of rock art in Australia has also been the focus of some research, and a report, *Conserving Australian Rock Art*, discusses in detail potential natural and human impacts as well as techniques for mitigating these impacts (Lambert 1989). All three of these reports contain useful techniques for documenting and preserving rock art. The most pertinent methods for recording and monitoring rock art in the *Colorado River Corridor* are reviewed below. Effective monitoring will require a consistent and systematic research and implementation program.

Rock art can be recorded in the field using manual or automated methods (Walt and Brayer 1994). Non-invasive manual recording methods include drawing, tracing, and computer aided drawing using a digital camera. Automated methods include standard still photography, terrestrial photogrammetric techniques, and video photography. Systematic and reproducible procedures for these and other recording methods have been developed by many researchers (see Walter and Brayer 1994; Loendorf, Olsen and Conner 1993; Lambert 1989; Hartley, Vawser, Smith and Johnson 1993). The cost, labor, and time required for each of these methods must be evaluated in light of the resources available to the monitoring program.

Still photography provides the easiest and most cost effective technique for recording and monitoring change to rock art (Fletcher and Sanchez 1994). For example, photographs of rock art sites near Gosford, New South Wales and Flanders Island, northeastern Queensland in Australia are being used to monitor pictographs for pigment loss (Lambert 1989:59). Methodological concerns regarding photographs, such as lighting, film, camera, lenses, time of day, and vantage point, have been discussed in detail and are relevant to the documentation and monitoring of rock art sites (see Loendorf, Olsen and Conner 1993; Walt and Brayer 1994; Hartley, Vawser, Smith and Johnson 1993; Brewer and Berrier 1984; Cole 1989). If still photography is to be adopted as a method for documenting change to rock art sites, a reproducible and systematic protocol should be adopted before the monitoring of rock art begins. Ultimately, photographs should enhance and not replace field measurements that are the foundations of most monitoring programs (Cole 1989:4).

Close range photogrammetry is another technique that can be used for detailed recording of rock art. This technique uses stereo photos to produce a contour image of rock art. The advantage of this method is that the topographic setting of the site can be recorded for map production at levels of accuracy and speed that surpass other theodolite and tape procedures (Hartley, Vawser, Smith and Johnson 1993:48). However, photogrammetric recording methods tend to be much more expensive and labor intensive than conventional photography.

Although Prince (1988) has developed a method for superimposing old photographs over current ones for the purpose of understanding changes to rock art sites, the digitization of photos would better serve both monitoring and archival purposes. Hartley, Vawser, Smith and Johnson (1993:39) have mentioned that digitization and rectification of photographic images holds great possibilities for analyzing and documenting rock art sites. Digital camera technology eliminates the need for film and does away with a step in the process toward digitization (Walt and Brayer 1994:27). However, digital cameras are quite expensive, being in the $10,000 range, and therefore are not necessarily cost effective for monitoring purposes. Although digitization of photographs requires both a high quality scanner and place to store the images, this technology is considerably less expensive.

Once rock art images have been captured, the most effective way of database storage and analysis is through digitization. These digital images should be stored in an industry standard format such as TIFF (Tagged Image File Format). Images can be catalogued using PC-DOS databases like Paradox and MS Access and stored in associated hard, CD-ROM, or tape drives.

Digital image processing using computer software can also prove to be useful in analyzing change images for monitoring purposes.

No matter what recording technique is adopted, rock art can be most profitably examined and monitored in relation to its locational setting (Hartley, Vawser, Smith and Johnson 1993:89). Identifying the geo-referenced location of rock art sites in the *Colorado River Corridor* can be accomplished through both conventional surveying techniques and the use of Global Positioning Systems (GPS). GPS units have been used at Petroglyph National Monument and Petrified Forest National Monument to identify the location of rock art sites with up to two meter horizontal accuracy. Accurate locational information is an important part of the monitoring process because it allows the distribution of rock art sites to be analyzed relative to natural features and processes (Walt and Brayer 1994:20). The spatial relationship of rock art sites to other elements of the natural and social environment can also be fruitful in interpreting cultural meaning. The association of a particular site with game migration trails is just one example (Fletcher and Sanchez 1994).

The report produced from the rock art demonstration project at Petroglyph National Monument suggests that ethnographic data be integrated with image and other text into one comprehensive database (Walt and Brayer 1994:51). This would require a computer system capable of multimedia operations as well as complex storage and query functions. The Southern Paiute Consortium has plans to develop this type of database for tribal purposes (see **Multimedia Database**).

Traditional Cultural Properties

TCPs are often elements of a region's topography and therefore are imbedded within the Southern Paiute cultural landscape. Photographic documentation will prove to be particularly useful in monitoring these resources because aesthetic and visual interpretations of these landmarks often reflect the cultural concerns of Southern Paiute people. The parameters for assessing impacts to TCPs must be determined through direct consultation with the Southern Paiute Consortium.

Animals

As described above, monitoring changes occurring to the entire ecosystem will help to better understand possible changes occurring to animals in the *Colorado River Corridor*. However, studies concerned with changes to plant populations are more evident because plants are easier to see, count, and measure. Changes occurring to specific animal species can be monitored through a number of well documented techniques. Scientists interested in understanding changes occurring to specific animal species document known extent of habitat, population size, population density and other elements of population dynamics. Understanding changes to vegetation that a specific species depends can also be an indicator of the health of a given animal population. The final draft of this report will contain more detailed information regarding these methods.

Other Considerations

Issues of sensitivity and privacy are also extremely important when discussing the management of Southern Paiute cultural resources. Monitoring cultural resource sites of concern to Southern Paiute people must be conducted by Southern Paiute monitors. If there is even the possibility of the removal or displacement of archaeological or plant materials at culturally significant sites, traditional spiritual person(s) designated by the tribes will be called upon to bless the area and provide guidance (Stoffle, Halmo, Evans and Austin 1994). The inclusion of such a person during monitoring trips is essential to the Southern Paiute monitoring process. The necessity for ceremonies at a given site should be documented on the monitoring form. After each Southern Paiute monitoring trip, monitors must provide a written report of their findings to the governments of the Kaibab Paiute Tribe and Paiute Indian Tribe of Utah.

MULTIMEDIA DATABASE

The Southern Paiute Consortium has documented the cultural significance and use of a sample of their cultural resources in the *Colorado River Corridor*. Certain concerns and recommendations that arose from these ethnographic investigations are being translated into parameters that can be monitored as part of the GCES-GIS (see above). However, issues relating to the sensitivity of these resources and educational concerns have prompted the Southern Paiute Consortium to begin development on a multimedia database of their cultural resources in the *Colorado River Corridor*. Data that is collected by research activities funded by the GCES can be entered into both the GCES-GIS and the Southern Paiute Consortium's multimedia database. The development of a separate tribally run and operated database permits the Southern Paiute Consortium: (1) to store and manipulate information about Southern Paiute cultural resources in a user-friendly database; (2) to monitor change in their cultural resources with the help of GCES-GIS; (3) and to develop a multimedia tool for educational purposes.

Multimedia refers here to the integration of audio, video, and text on a personal computer. A multimedia database is ideal for storing and retrieving information regarding Southern Paiute cultural resources because inventories that have already been conducted include audio tape, still photos, video, and site specific textual data. Monitoring data, which will include both textual and visual data, can also be integrated into this database. This will allow the Southern Paiute Consortium to assess some of the changes occurring to Paiute resources in the *Colorado River Corridor*. The integration of these different media provides a holistic understanding of Southern Paiute cultural resources. In a sense, the multimedia database allows the user to "virtually" visit the *Colorado River Corridor*, from the perspective of Southern Paiute people. The Southern Paiute Consortium is comprised of the Paiute Indian Tribe of Utah (PITU), including the Cedar City and Shivwits bands, and the Kaibab-Paiute Tribe of northern Arizona. All of these separate Paiute communities will require both personal computers and trained personnel to monitor areas of concern in the future.

This multimedia database would store all the information the Southern Paiute Consortium has accumulated regarding cultural resources in the *Colorado River Corridor*. It can also be expanded to include other cultural landscapes, like Zion National Park in Utah. A separate tribally operated database allows the Southern Paiute Consortium to manipulate and use the information they are helping to integrate into the GCES-GIS.

Data Transfer

The first step in developing a Southern Paiute multimedia database is to obtain relevant images and data from the GCES-GIS. This information provides some baseline information about the natural resources in the *Colorado River Corridor* as well as a geographic context for data about Southern Paiute cultural resources. As these images are updated by the GCES they can also be used to update the Southern Paiute Consortium multimedia database.

The images that would be of great interest to the Southern Paiute Consortium include (1) the entire *Colorado River Corridor* (1:24,000 USGS quads) and (2) aquatic, terrestrial, and sediment data for the entire *Colorado River Corridor* at 1:2,400 scale and larger. The Southern Paiute Consortium has to have the ability to receive and store this data. The cartographic and associated tabular data stored in an Arc/Info format at the GCES-GIS requires very large digital storage capabilities. There are two existing ways to receive this data: digital tape (4mm,8mm or DAT) or via remote on-line access such as the Internet (i.e. The Information Superhighway). In the latter case, a storage device would still be required once the data had been transferred. In addition, the infrastructure needed to transfer data via the Internet does not exist on the Kaibab-Paiute, Moapa and Shivwits Reservations. Consequently, the Southern Paiute Consortium's must acquire a digital tape device to access the GCES-GIS data.

The multimedia database should utilize an IBM-PC compatible computer that is running the most recent version of DOS (currently DOS 6.22) and Windows (currently MS Windows 3.11). This computer should also include the following hardware specifications: Pentium or RISC-based microprocessor (currently not available) running at 100 MHz or higher, 17 or 21 inch monitor with high resolution and refresh rates, 16 bit audio card with stereo speakers, graphics accelerator (preferably with at least 2MB of VRAM), at least 32MB of RAM, at least 1 GB hard drive with 256K cache, and a quad speed CD-ROM drive. The cost and specifications of two potential computer systems are described below.

For $4900, Dell Computer Corporation sells a Pentium based processor running at 100MHz with the following specifications: Imagine 128 Graphics Accelerator with 4MB VRAM, 32MB RAM, quad speed CD ROM drive, 1GB hard drive with 256K cache, 17" Dell NI monitor with high resolution and refresh rates, one 3.5" diskette drive, MS DOS 6.2, MS Windows 3.1, and a microsoft mouse. A 16 bit audio card with speakers will cost an additional $200. For $4600, Zeos International Ltd. markets a Pentium processor running at 100MHz with the following specifications: 32MB RAM, quad speed CD ROM drive, Diamond Stealth graphics accelerator with 2MB VRAM, 17" Zeos SVGA NI monitor with high resolution and refresh rates, one 3.5" diskette drive, microsoft mouse, MS DOS 6.2, MS Windows 3.1, and a 16 bit sound card with stereo speakers.

In addition, the Southern Paiute Consortium should purchase a tape or cartridge drive for storage and database access and a flat screen scanner for digitizing photographs. A 4mm or 8mm tape backup drive will cost between $1000 and $1500 while a high quality scanner will cost between $500 and $1000.

A software package such as Director 4 or Tool Box will also have to be purchased in order to create a user-friendly Graphical User Interface (GUI) from which all types of cultural resource data (textual, graphical, and audio) can be accessed and manipulated. This type of "authoring software" ranges in price from $200 to $1000. It is also recommended that the Southern Paiute Consortium purchase an image editing software program such as Adobe Photoshop as well as a user friendly PC based GIS tool such as PC Arv/View 2.0. Many high quality scanners are packaged with Adobe Photoshop so this software will probably not have to be purchased separately. PC Arc/View is currently priced at around $900. This program would allow the Southern Paiute Consortium to easily view and analyze GIS related images that they receive from the GCES.

One of the features of the multimedia database will be its expendability. Data from outside the affected zone will be included in the database. Areas where other ethnographic inventories have and will be conducted, such as Willow Canyon and Zion National Park, can be added when time and resources become available.

Education and Multimedia

One of the prime purposes for the development of a multimedia database is to store information about Southern Paiute culture, including information about the Southern Paiute mythology and language and the Southern Paiute cultural landscape. However, storing this type of information is only useful when it can be used for educational purposes. Cultural knowledge about plants, animals, and the natural environment can be imparted to Southern Paiute youth through the use of sound, text, and pictures. The incorporation of this computer database into the school curriculum of Southern Paiute children would prove invaluable in teaching them about their rich living heritage. Not only will it provide them with a source of knowledge about their culture but also practical experience with computers. The use of audio, video and text allows a wide variety of people, who have previously been unable to visit the Grand Canyon, to learn about how the Southern Paiute people are connected to the Colorado River and the beautiful canyon it has formed.

CONCLUSION

The incorporation of the Southern Paiute Consortium's concerns into the Glen Canyon Environmental Studies-Geographic Information System (GCES-GIS) long range monitoring plan, allows a more comprehensive understanding of how cultural resources in the *Colorado River Corridor* are being impacted over time. GIS provides one mechanism by which people in different organizations, different levels of government and different disciplines can come together around a common resource to share the process of solving common problems. The Southern Paiute Consortium contributes to this monitoring process by identifying the location and size of areas of concern in the *Colorado River Corridor* and providing monitoring data about these areas to the GCES for integration into the GIS. Research in FY1995 will be directed towards the development and implementation of a monitoring program that is approved by the Southern Paiute Consortium.

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APPENDIX A

LOCATION OF LONG-TERM MONITORING SITES

A GCES-GIS work group that included federal and state agency representatives, Native Americans, and members of other groups identified 15 sites that would be the focus of the long range monitoring plan, special studies, and the archive. The locations of these long-term monitoring sites are shown on the map.

Glen Canyon Environmental Studies

Location of Long-Term Monitoring Sites

Long-Term Monitoring Sites

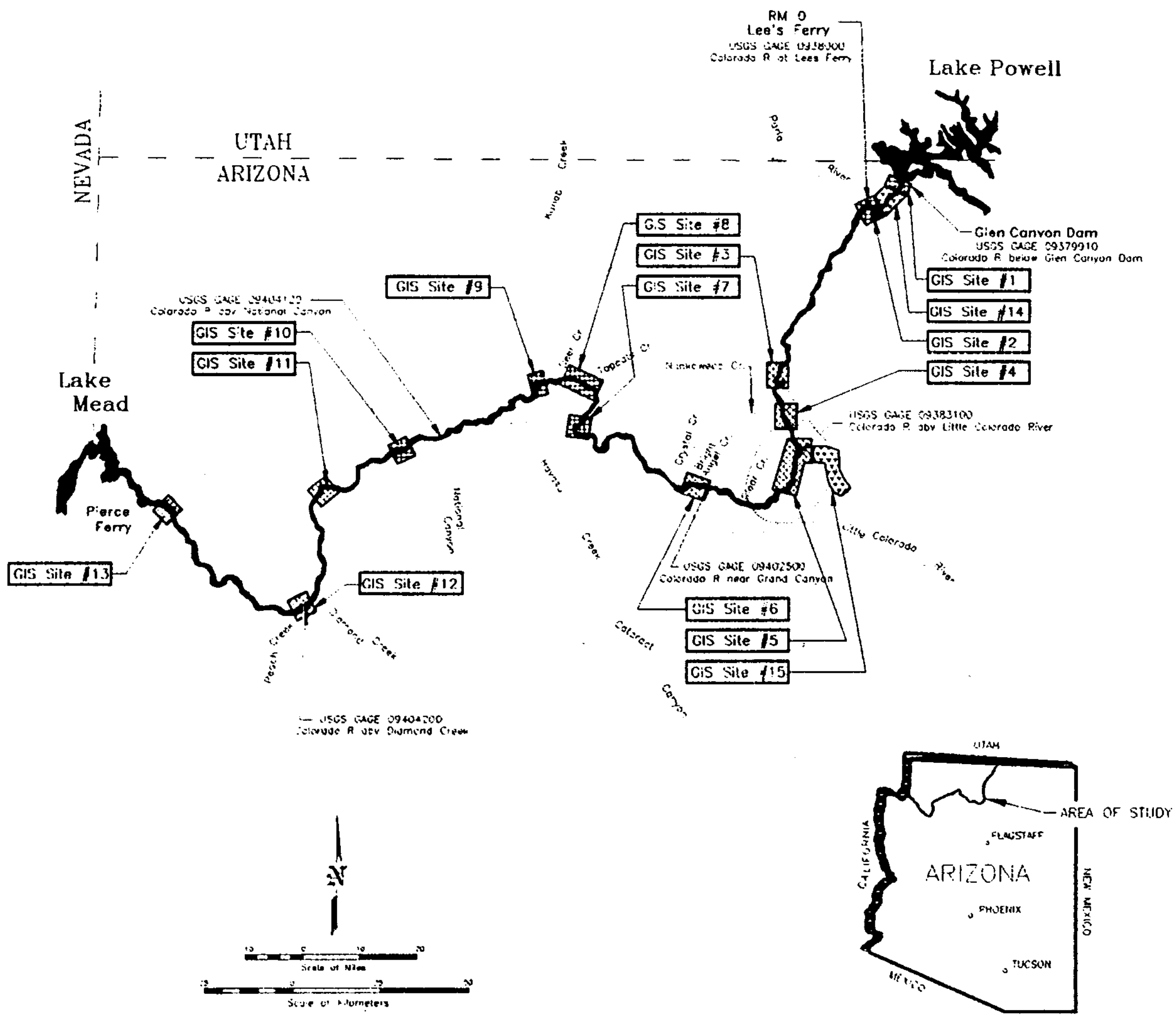
SITE	LOCATION	RIVER MILE
1	GLEN CANYON DAM	DAM to -10.5
2	LEE'S FERRY	-4 to 2
3	PRESIDENT HARDING	42 to 48
4	NANKOWEAP	51 to 56
5	LCR to CARDENAS	60 to 72
6	GRANITE to CRYSTAL	93 to 99
7	BLACKTAIL	120 to 123
8	TAPEATS & DEER CREEK	133 to 138
9	KANAB CREEK	143 to 145
10	LAVA FALLS	179 to 181
11	GRANITE PARK	207 to 210
12	DIAMOND CREEK	225 to 230
13	COLUMBINE FALLS	273 to 276

Special Study Sites

SITE	LOCATION	RIVER MILE
14	HIDDEN SLOUGH	-10.4 to -4.1
15	LCR	LCR 1.5 to LCR 12
16	To Be Announced	

Legend

- Location of Geographic Information and Long-Term Monitoring Sites
- Special Study Sites
- Colorado River Corridor
- Grand Canyon National Park
- Tributaries
- State Borders



APPENDIX B

GRAND CANYON NATIONAL PARK ARCHAEOLOGICAL SITE MONITORING FORM

Grand Canyon National Park

RIVER CORRIDOR ARCHAEOLOGICAL SITE MONITORING FORM

MANAGEMENT

1. Site Number AZ: ____________ 2. Monitor Session ____________

3. River Mile ______ Bank (L/R/B): ____ 4. Date ____________

5. Monitor (s) ________________________________

6. Site Type ________________________________

NATURAL IMPACTS

0 = Absent; 1 = Present; 2 = Increase; 3 = Decrease; 4 = NA (for items 7 - 14)

		Structures / Storage	Artifacts	Roasters/ Hearths	Perishables/ Middon	Rock Art	Other
7.	Surface Erosion (0-10cm)						
8.	Gullying (10-100cm)						
9.	Arroyo Cutting (>1m)						
10.	Bank Slumpage						
11.	Eolian/Alluvial Erosion/Deposition						
12.	Side Canyon Erosion						
13.	Animal-Caused Erosion (trailing,burrowing)						
14.	Other Natural Impacts (spalling, roots)						

15. If arroyos or gullies are present, do they drain to the river? (Note: Some drainages die out in dune fields or on terraces before reaching the river.) 0 = no; 1 = yes; 2 = NA ____________

16. Do any of the above impacts appear to have occurred since the last monitoring episode? 0=no; 1=yes If yes, explain in 17. ____________

17. Comments:

HUMAN IMPACTS

Site Number :

Monitor Session :

0 = Absent; 1 = Present; 2 = Increase; 3 = Decrease; 4 = NA (for items 18 - 24)

18.

	Structures / Storage	Artifacts	Roasters/ Hearths	Perishables/ Midden	Rock Art	Other
Visitor Impacts						

19. Collection Piles: If present, explain in 26. ________
20. Trails: If present, explain in 26. ________
21. On-site Camping: If present, explain in 26. ________
22. Criminal vandalism/ARPA violations: If present, explain in 26. ________
23. Other: If present, explain in 26. ________
24. Human Impacts since last monitoring: ________
25. Are any human impacts directly related to river fluctuations and/or dam operations? 0 = no; 1 =yes If yes, explain in 26 (i.e., development of new trails to avoid high water, availability of new beaches in proximity of site). ________
26. Comments:

MANAGEMENT ASSESSMENT AND RECOMMENDATION

27. Monitor Schedule: 1) discontinue 2) semiannually 3) annually 4) every-other-year 5) every three to five years ________
28. Monitor with a stationary camera: 0 = no; 1 = yes ________
29. Recommended measures to reduce site impacts: 0 = no; 1 = yes

    Retrail ______ Plant vegetation ______ Stabilize ______

    Obliterate trail(s) ______ Install check dams ______ Close site to visitors ______

30. Recommended measures to protect the site's integrity: 0 = no; 1 = yes

    Surface collect entire site ________ Test for depth of subsurface cultural deposits ________

    Map as a form of data recovery ________ Excavate entire site ________

31. Comments: (i.e., surface sample unit)

APPENDIX C

CANYONLANDS RAPID ESTIMATION PROCEDURE AND SEQUOIA METHOD OF MEASUREMENTS ON PERMANENT PLOTS

The Canyonlands Rapid Estimation Procedure (Taken from Cole 1989)

This procedure is similar in many ways to the procedure used in the Bob Marshall; however, more information is collected and impact parameters have been adapted to desert environments. They also use slightly different forms to monitor sites used primarily by three different types of use: backpackers, river floaters, and people on four-wheel drive. Information on site characteristics is collected; the site is quickly mapped; photopoints are established; and an impact rating form is filled out.

The form (fig. 15) provides ratings for 24 parameters. The ratings include weights; some vary from 1.5 to 6, while others vary from 0.5 to 2. These ratings are summed. Then the condition of each site is considered to be excellent if this sum is between 25 and 37. It is considered good, fair, or poor if the sum is 38 to 62, 63 to 87, or 88 to 100, respectively.

Many of the ratings involve comparisons between the campsite and an adjacent undisturbed area, as described for the Bob Marshall procedure (appendix H). Most others should be self-explanatory from the form (fig. 15), although many definitions need to be agreed on by different field workers. For example, for tree and shrub damage, how much damage must occur for it to be counted?

1. VEGETATION COVER								
a. % cover	<10% reduction when compared with adjacent undisturbed area.	1.5	10-30% reduction.	3	30-60% reduction.	4.5	>60% reduction.	6
b. Composition	No exotic or disturbance species present.	1	10-20% of vegetation composed of exotics/ disturbance species.	2	20-50% exotics and/or disturbance species.	3	>50% exotics and disturbance species.	4
c. Distribution	Vegetation evenly distributed throughout site.	0.5	Faint appearance of isolated "islands" of vegetation.	1	Up to 30% of vegetation built up around shrubs and "islands" of vegetation.	1.5	>30% of vegetation built up around shrubs and "islands" of vegetation.	2
2. SOIL DISTURBANCE								
a. Cryptogamic crust	No disturbance; still intact in appropriate habitat.	1	<30% reduction of crust when compared to adjacent/undisturbed area.	2	30-60% reduction of crust.	3	>60% reduction of crust.	4
b. Compaction/ loosening/ erosion	None apparent.	1	<30% of soil in site shows compaction (fine soils) or loosening (coarse soils).	2	30-60% of soil shows compaction or loosening; signs of erosion or gullying in 2 locations.	3	>60% of soil shows compaction or loosening; signs of erosion in 2 locations.	4
c. Excavations and trenches	None apparent.	1	1 or 2 small trenches or excavations.	2	2-4 excavations or trenches; a few may show slight erosion.	3	>4 excavations or trenches; some show erosion and gullying.	4
3. LITTER								
a. % cover	<10% disturbed.	1	10-35% reduction in contrast to adjacent/undisturbed areas	2	35-70% reduction compared to adjacent/ undisturbed areas	3	>70% reduction compared to adjacent undisturbed areas.	4
b. Distribution	Evenly distributed.	1	50% of litter around edge of site and stable objects	2	50-80% around edge and stable objects.	3	>80% of litter around edges and stable objects.	4
c. Condition	No obvious signs of broken and crushed litter.	1	Slight appearance of crushed and broken litter.	2	<60% appears crushed or broken	3	>60% appears crushed or broken.	4
4. SIDE TRAILS								
a. Number	Only 1 present: not very obvious from main trail to or through site; no spur trails, and only a few isolated footprints present.	1	2 distinct trails from main trail to site or between attraction site (arch site or spring); no spurs; few isolated footprints.	2	3 distinct trails from main trail to site or between attraction site; 3 side trails or spurs developing; footprints apparent.	3	3 distinct trails from trail to site; 3 side or spur trails developing; trails have begun to merge; numerous footprints in and around trail and site.	4
b. Width	Average width <12".	1	Average width of 1 trail >12".	2	2 trails wider than 12".	3	>2 trails wider than 12"; trails merging.	4
c. Depth	Trail at same level as adjacent area.	1	1 trail-wearing below level of adjacent area.	2	At least 2 trails deeper than adjacent ground level.	3	All trails deeper than adjacent ground level.	4
5. SHRUB DAMAGE								
a. % damaged reduced vigor	None show any damage.	1.5	<10% of shrubs show damage (such as broken limbs, crushed appearance).	3	10-30% of shrubs show damage; 1 or 2 show reduced vigor as a result of damage.	4.5	>30% of shrubs show damage; 2 show reduced vigor; dead or dying shrubs present.	6
b. Root exposure	No roots exposed.	1.5	Exposed roots on 1 shrub.	3	Exposed roots on 2 shrubs.	4.5	Exposed roots on 3 shrubs.	6
6. TREE DAMAGE								
a. Broken limbs, gashes, damage	No damage; or no trees present.	1	<10% of trees have broken limbs, gashes, or other damage.	2	10-35% of trees have broken limbs, gashes, or other damage.	3	>35% of trees have broken limbs, gashes, or other damage.	4
b. Root exposure	No roots exposed; or no trees present.	1	1 root exposed in site.	2	2 roots exposed in site.	3	3 or more roots exposed in site.	4

7. HUMAN WASTE								
a. Toilet paper	None present.	1	1-2 pieces of toilet paper present.	2	3-4 pieces of toilet paper.	3	4 pieces of toilet paper.	4
b. Fecal matter	None present.	1	1 pile of feces encountered.	2	2 piles of feces.	3	>2 piles of feces encountered.	4
8. FIREPITS								
a. Number	None present.	1	Sign of 1 small firering (<2' diameter)	2	1 firering >2' diameter.	3	>1 firering.	4
b. Rock scarring	None.	1	<25% of rocks show fire scars.	2	26-50% of rocks show fire scars.	3	>50% show fire scars.	4
c. Charcoal and ash	None present.	1	Small trace of charcoal and ash concentrated in 1 pile; site can be easily returned to natural or undisturbed condition.	2	Concentrated pile of charcoal and ash in obvious pile.	3	Charcoal and ash scattered throughout site, mixing into soil.	4
9. ROCK DISPLACEMENT	None.	1	1-5 small rocks (6" diameter) moved; no tables or seats constructed.	2	>5 rocks moved; no tables or seats constructed	3	>5 rocks moved; tables, seats, and other items constructed.	4
10. TRASH	None present.	1	<4 pieces of trash, biodegradable or non-biodegradable.	2	4-6 pieces of trash.	3	>6 pieces of trash.	4
11. PESTS AND INSECTS	None.	1	1 small ant colony in or at edge of site.	2	1 ant colony; ants in <50% of site; few scattered signs of rodents within 20' of site.	3	>1 ant colony; ants throughout site; numerous signs of rodents: tracks, burrows, nests within 20' of site.	4

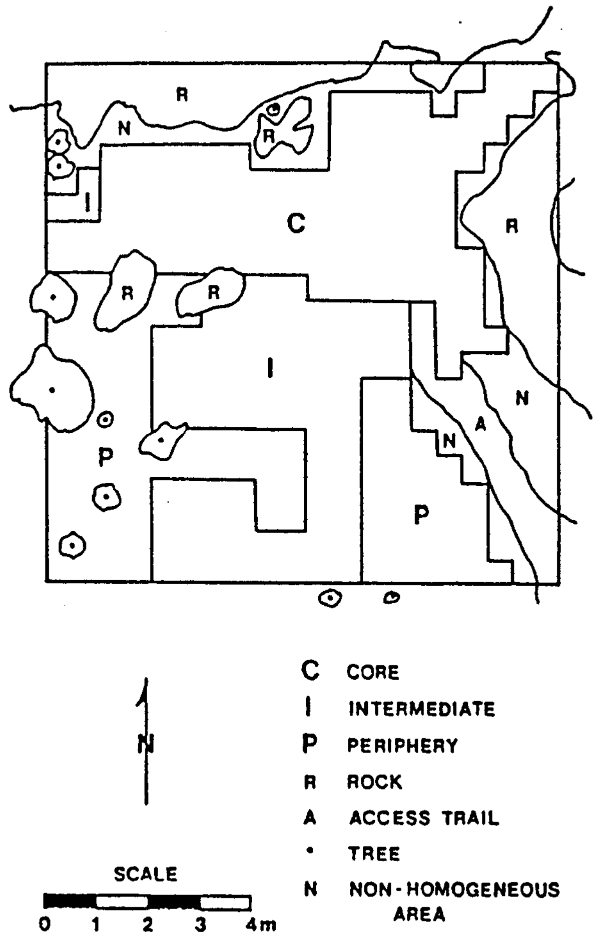
Excellent (E) = 25-37
Good (G) = 38-62
Fair (F) = 63-87
Poor (P) = 88-100

The Sequoia Method of Measurement on Permanent Plots (Taken from Cole 1989)

Establish a 32.8- by 32.8-ft (10- by 10-m) sampling unit, aligned along compass directions and located such that most of the campsite is included. Place permanent markers (such as buried nails) at each corner and reference at least one corner. (Refer to the appendix section on photopoints for a discussion of referencing.) Place temporary stakes at 3.28-ft (1-m) intervals along each side. Connect stakes with string to form a 100-cell grid of 10.76-ft^2 (1-m^2) sections.

Subdivide each section mentally into four 2.69-ft^2 (0.25-m^2) plots. Stratify each of these plots subjectively into core, intermediate, and periphery (essentially control) plots. Core plots are generally in the center of the site and show nearly complete loss of vegetation and organic matter and continuous disturbance of the mineral soil. Intermediate plots show notable but less substantial damage (more vegetation cover, less litter and duff pulverization, and pockets of intact sod). Periphery plots appear to be unimpacted and border the site. Map each zone (see fig. 11) and take a subsample of five to 10 plots randomly from each zone.

In each plot, estimate the foliar cover of each plant species to the nearest 5 percent (to the nearest 1 percent if cover is less than 5 percent). Collect five to 10 soil samples from each zone to analyze bulk density, soil moisture, soil texture, organic matter content, pH, and chemistry.



KAIBAB PAIUTE TRIBE

Cultural Resources

OVERNIGHT DELIVERY

May 11, 1995

RECEIVED
MAY 12 1995

Mr. David Wegner, Project Leader
Glen Canyon Environmental Studies
121 East Birch, Suite 307
Flagstaff AZ 86001

RE: May 12th Deadline Draft Report

Dear Dave:

Enclosed please find the following draft reports: (1) *Tumpituxwinap (Storied Rocks):Southern Paiute Rock Art in the Colorado River Corridor Version 1* (2) *Southern Paiute Cultural Resource Monitoring in the Colorado River Corridor: A Preliminary Chapter to be Incorporated in the Third and Final Report.*

To meet the deadline of May 12th for the Draft Report, we are sending one set today and will send two more copies of each in the near future.

Should you have any questions or need additional copies, please call me.

Sincerely,

Angelita S. Bulletts
Southern Paiute Consortium

HC 65 Box 2 Pipe Spring AZ 86022 (602) 643-7214