RESOURCE BASELINE INVENTORY

GREAT BASIN NATIONAL PARK

COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT

University of Nevada, Las Vegas - National Park Service

The National Park Service and the University of Nevada signed a Master Agreement on November 4, 1971 that provided for the establishment and operation of this Unit on the Las Vegas Campus. The Unit, although located in the Department of Biological Sciences, is geared to provide a multidisciplinary approach that utilizes all talents on the University Campus to natural resources studies in areas administered by the National Park Service. Primary attention of this Unit is directed to Death Valley National Monument, California/Nevada; Great Basin National Park; Lake Mead National Recreation Area, Nevada/Arizona; and Joshua Tree National Monument, California.

Through the direction and coordination of the Unit Leader, projects are undertaken in these areas that are designed to provide scientific facts upon which the park managers may make appropriate decisions and formulate and implement effective management action plans. Through close association with faculty members and through guidance of graduate students, a greater awareness of problems and needs of the Service are recognized and academic interests are channelized to participate with the National Park Service in studies of mutual interest and concern.

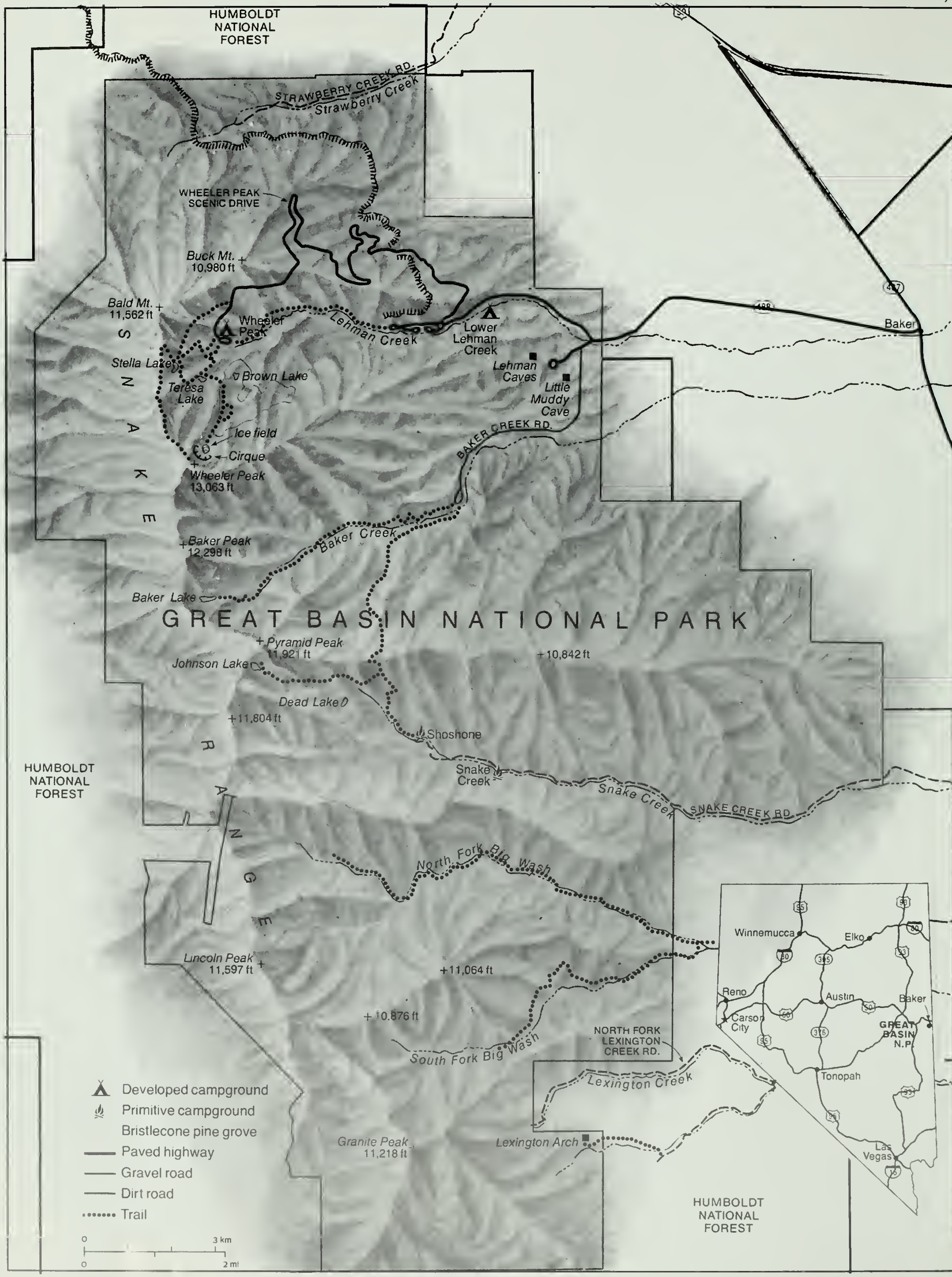
NOTICE: This document contains information of a preliminary nature, and was prepared primarily on an interim basis. This information is not intended for use in open literature prior to publication by the investigators named unless permission is obtained in writing from the Unit Leader.

GREAT BASIN NATIONAL PARK SPECIAL PUBLICATION NO. 1
NPS/WR GRBA/92-01

RESOURCE BASELINE INVENTORY WORKSHOP

JANUARY 19-21, 1988
UNIVERSITY OF NEVADA, LAS VEGAS

GREAT BASIN NATIONAL PARK


HUMBOLDT NATIONAL FOREST
STRAWBERRY CREEK RD.
Strawberry Creek
WHEELER PEAK SCENIC DRIVE
Buck Mt. 10,980 ft
Bald Mt. 11,562 ft
Wheeler Peak
Lehman Creek
Lower Lehman Creek
Lehman Caves
Little Muddy Cave
Stella Lake
Brown Lake
Teresa Lake
Ice field
Cirque
Wheeler Peak 13,063 ft
BAKER CREEK RD.
Baker Creek
Baker Peak 12,298 ft
Baker Lake
SNAKE RANGE
GREAT BASIN NATIONAL PARK
Pyramid Peak 11,921 ft
Johnson Lake
+10,842 ft
Dead Lake
+11,804 ft
Shoshone
Snake Creek
Snake Creek
SNAKE CREEK RD.
HUMBOLDT NATIONAL FOREST
North Fork Big Wash
Lincoln Peak 11,597 ft
+11,064 ft
+10,876 ft
South Fork Big Wash
NORTH FORK LEXINGTON CREEK RD.
Lexington Creek
Granite Peak 11,218 ft
Lexington Arch
HUMBOLDT NATIONAL FOREST
Baker
488
487
50
Winnemucca
Elko
Reno
Austin
Carson City
Baker
GREAT BASIN N.P.
Tonopah
Las Vegas
95
80
93
305
50
376
15
Developed campground
Primitive campground
Bristlecone pine grove
Paved highway
Gravel road
Dirt road
Trail
0 3 km
0 2 mi

FORWARD

This publication represents an effort by the National Park Service (NPS) to assess the extent of our knowledge of park resources and determine the logical sequence for acquiring vital information in order to advance our understanding and ability to protect the natural and cultural resources of Great Basin National Park. The assessment process began with hosting an interdisciplinary Resource Baseline Inventory (RBI) Workshop at the University of Nevada, Las Vegas in January 1988, for the purpose of developing the natural resource component of the Natural and Cultural Resource Management Plan for the 49th and then newest national park in the System. After orienting the participants to the Park's natural resources and related issues, the workshop created a logic flow diagram or Step Down Chart outlining the information required at each "step" before proceeding to the next level of complexity. The Step Down Chart then guided the RBI Workshop as the participants wrote project statements for future research and resource management actions. Following the RBI Workshop, the Park staff has used the Chart to evaluate and prioritize research and resource management actions. It has also expanded upon the Workshop's interdisciplinary approach to include integrating databases through the use of a computerized Geographic Information System (GIS), developing standard methodologies for the long-range monitoring of resources, and incorporating cultural and sociological resource concerns. The starting point for the logic flow diagram or Step Down Chart is this paraphrased clause from the enabling legislation: "to conserve and protect the scenic, natural and cultural resources of Great Basin National Park by such means and manner as to leave them unimpaired for the public use and enjoyment of future generations, subject to the provisions of Public Law 99-565".

Since the RBI Workshop only dealt with the natural resources, subject experts were sought to develop Step Down Charts and Research Perspectives for the historic, archaeologic, and socio-economic aspects of the legislative mandate. We are alerted to the fact that their publication is an assessment at one point in time, and that the RBI process is a dynamic one requiring updates and refinements to the Step Down Chart, Research Perspective, and related components. Nonetheless, I applaud their ambitious interdisciplinary effort to understand natural and cultural phenomena and evaluate the effects of external threats.

We must remember that within the past 20 or 30 years many NPS areas were not particularly concerned about defining their resource baseline for essentially two reasons: assimilating vast quantities of data with their variety of formats was practically impossible; and external threats were minimal, if recognized, so environmental change was frequently attributed to "natural" causes. Neither situation is true today!

The enormous data sets and variety of formats can be integrated, analyzed, and graphically displayed with relative ease using the GIS computer software. NPS areas are no longer immune to man's tampering with his environment, and are facing regional, national, and global impacts on a scale heretofore unknown: global warming caused by increases in atmospheric concentrations of "greenhouse" gases, urban and recreational development encroaching upon national parks and forests to form natural islands and genetic isolation for wildlife and plants, acid rain deposition sterilizing lakes and streams, and water rights disputes and water pollution problems complicating our attempts to preserve natural hydrological systems. These are just a few of the external threats impacting otherwise pristine areas.

Few people realize that each park must compete with other NPS areas for research monies, and will probably never be able to fund all of their identified needs through NPS sources alone. For this reason, it is important that this publication also serve to attract independent research, particularly if the Park staff makes presentations at interested universities and introduces faculty and students to the research opportunities identified in the Step Down Charts and Research Perspective. The information contained in these sections is especially valuable to prospective researchers because it enables them to assess their interests and expertise against Park priorities. Potential researchers also need to be aware that the Park can support independent studies in many ways other than direct financial aid.

As you read through this document, please consider our national parks as unique natural laboratories for evaluating human impacts, protecting relatively pristine environments, and enhancing the public educational and recreational opportunities.

James M. Ridenour
Director
National Park Service

Photo by Mike Nicklas

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ACKNOWLEDGEMENTS

Our original objectives for a Resource Baseline Inventory (RBI) Workshop were similar to what several other National Park Service areas had previously done: determine the extent of site specific scientific knowledge, develop project statements on critical issues for their Resource Management Plan, and formulate research proposals. The RBI Workshop process provides some immediate advantages to park management including a reference bibliography, guidance in planning resource-based management actions, and competitive research proposals. Great Basin National Park realized these benefits as well, but I undertook to document the RBI Workshop process and expand upon it. I am indebted to Anne Marie LaRosa for introducing me to the RBI Workshop concept and assisting Dr. Charles Douglas and myself in its organization.

As our plans for the RBI Workshop progressed, other objectives and applications became evident, particularly the demands of park planning and the need to attract independent studies. In the first instance, an RBI database provided valuable information for the General Management Plan (GMP) and the accompanying Environmental Impact Statement. This NPS planning effort will determine the course of action for park management and the construction of new facilities over the next 10 to 15 years. Several NPS technical specialists warrant recognition for their conscientious support. I especially wish to thank the following speakers and participants: Bart Young, GMP Team Leader, introduced the park planning process to the RBI Workshop participants and gave them another sense of purpose. Gary Waggoner assisted by providing Geographic Information Systems (GIS) computer graphics to further orient participants to the natural resource concerns; illustrating current knowledge and demonstrating how computers can integrate and analyze large databases. Dr. Stan Ponce and Owen Williams of the Water Resources Division shared their wealth of knowledge on water rights, quantities, and qualities.

Time and cost considerations forced us to restrict the RBI Workshop to natural resource concerns. This left obvious voids in cultural resources, history and archeology, as well as the socio-economic factors of visitor use. To complete our RBI analysis, I sought the assistance of several researchers, and am certainly thankful for their contributions. Harlan Unrau, a historian at the NPS Denver Service Center, developed the Step Down Chart for history and the summarizing section in the Research Perspective. Dr. George Teague and Susan Wells of the NPS Western Archeological and Conservation Center contributed similar material for archeological resources. Drs. Marty Lee and Perry Brown of Oregon State University were in the midst of visitor use research at the Park and graciously fulfilled our needs with a Step Down Chart and the related text for socio-economic factors. Dr. David Taylor of the University of Wyoming is currently investigating the economic impacts of the Park and offered some valuable suggestions. Artists, Jan Gunlock and Carole Thickston, generously allowed us to use their talents to highlight the aesthetic qualities of the Park. A special thank you is extended to Senator Bryan for providing his 1988 campaign poster to depict the basin and range characteristic of the Great Basin physiographic region on the cover.

As this publication evolved, many encouraged me through their enthusiasm, suggestions and review comments. Superintendent Al Hendricks recognized the importance of research and resource management to our understanding of unique park resource and its value in making sound management decisions. He also participated in the workshop, applied the information gained, and funded this publication. Dr. Charles Douglas, an NPS employee on the University of Nevada, Las

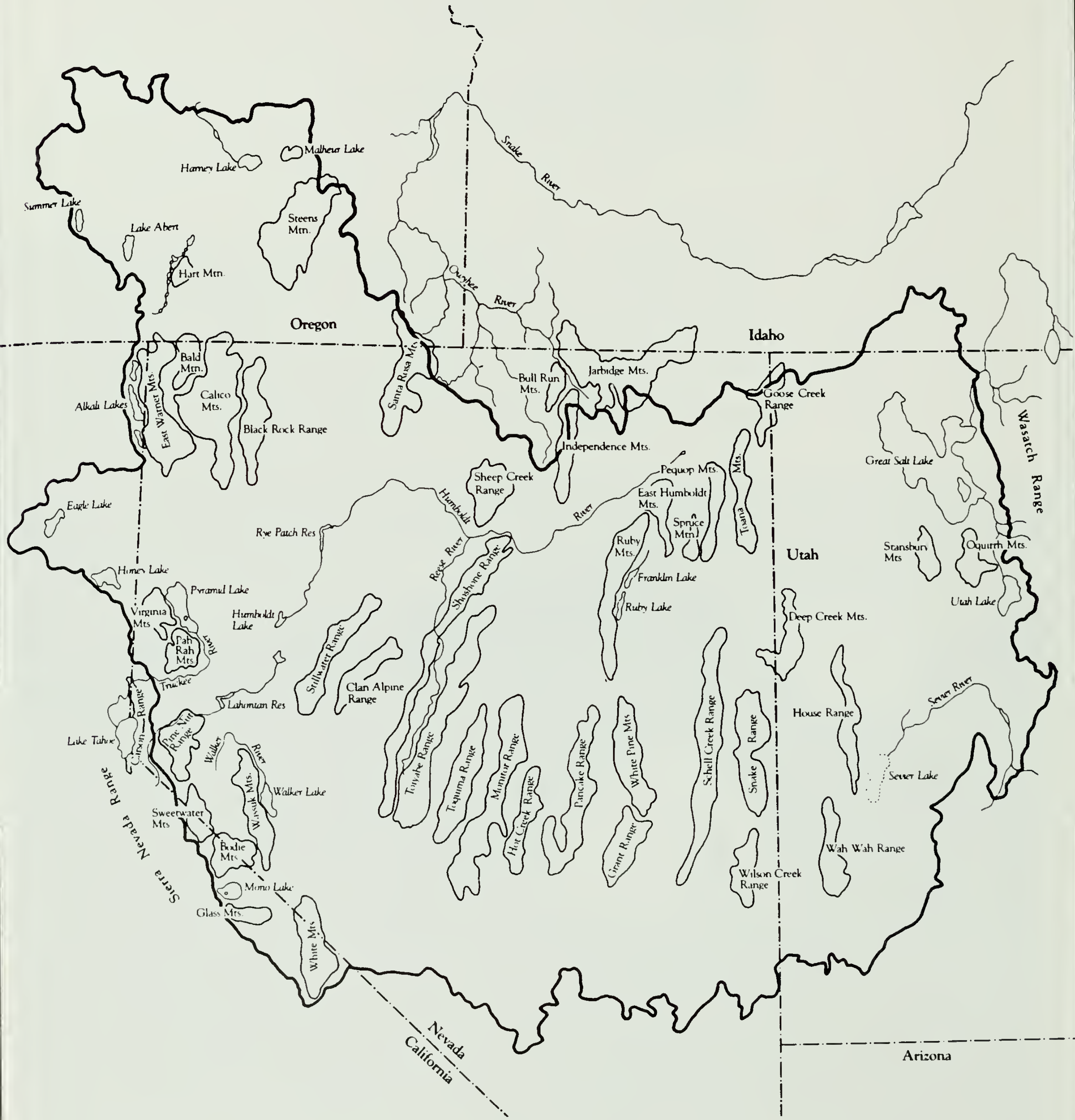
Vegas faculty was constantly supportive and deserves my sincere gratitude. Gary Davis, a marine biologist at Channel Islands National Park, was an excellent facilitator at the RBI Workshop. Lastly, I am most appreciative of the seemingly endless administrative work performed by Kathleen Gonder of the Park staff.

Bruce L. Freet

Bruce L. Freet
Chief, Interpretation & Resource Management
Great Basin National Park

Photo by Mike Nicklas

The Great Basin, showing principal mountain ranges, rivers, and lakes.



From *Birds of the Great Basin* by Fred A. Ryser, Copyright 1985 University of Nevada Press.

INTRODUCTION

A Resource Baseline Inventory (RBI) Workshop was held at the University of Nevada, Las Vegas from January 19 to 21, 1988 for the purpose of developing a tactical plan for natural resource management and research at the recently established Great Basin National Park. Upon invitation, 14 researchers attended representing seven universities and an array of disciplines: range management, forestry with an emphasis on riparian zones, botany with an emphasis on alpine zones, ornithology, herpetology, and invertebrate biology. They were joined by 10 National Park Service employees and three representatives from others agencies to contribute their expertise in such diverse fields as park management, park planning, resource management, plant ecology, fire ecology, fisheries and wildlife biology, and geographic information systems. We had planned for representation of research in geology and cave management, but unexpected schedule conflicts left us without participants.

Great Basin National Park was created on October 27, 1986 "in order to preserve for the benefit and inspiration of the people a representative segment of the Great Basin of the Western United States possessing outstanding resources and significant geological and scenic values,..." (Public Law 99-565). It joined 48 other national parks which preserve unique natural and cultural resources. The park incorporated 76,460 acres of Humboldt National Forest including 28,000 acres of the Wheeler Peak Scenic Area, plus 640 acres of Lehman Caves National Monument for a total of 77,100 acres. It is located in the South Snake Range in White Pine County, Nevada about 70 miles east of Ely and 5 miles west of Baker. The park ranges in elevation from 6,200 feet to Wheeler Peak's 13,063 feet with several plant communities being represented, including a variety of endemic species. The views along the roads and trails offer extensive vistas of Great Basin geology beyond the Park.

As directed by Congress, the National Park Service (NPS) must prepare a General Management Plan (GMP) to guide long term management and park development. Collating and analyzing natural and cultural resource baseline information is an important first step in this process. The GMP will use this information to formulate its alternatives for future management, and ultimately the approved GMP will determine the park management priorities and direction.

The following objectives were developed to guide the RBI process toward achieving a tactical resource management plan, with research designed to fulfill the identified management needs:

1. Provide a bibliography of reference literature to assist the park in developing a research library.

2. Respond (provide feedback) to the GMP team presentations — make suggestions for park planning; changing the approach, developing other subjects or themes, and expanding the literature search or contacts with consultants.

3. Determine RBI needs and establish priorities — review the available information, determine any deficiencies, and prioritize needs. (This assumes a prior information exchange and is part of the Step Down Chart process.)

4. Write project statements to reflect the identified RBI needs and priorities, and assemble them into a prioritized list (differentiate between resource monitoring and research).

5. Write research proposals following the NPS format for the top priority needs.

When the products of the RBI Workshop were collated, two obvious questions still lacked answers: Precisely where on the Step Down Chart is the NPS now in acquiring a natural resource baseline inventory for the Park; and What does this baseline information actually consist of. Two natural resource Step Down Charts were developed in response to these questions, and a Research Perspective section added to the text to describe the known baseline information.

The more one delved into the literature and attempted to describe baseline for the Park, the more the lack of Step Down Charts for cultural resources and socio-economic activities hindered the effort. These elements along with natural resources reflected the legislative mandate and primary management objectives. The absence of cultural resource and socio-economic activity charts was accentuated further by the NPS funding several research projects in these disciplines soon after the Park was created to support the General Management Plan. In order to gain an overall perspective of what these research projects were accomplishing, cultural resource and socio-economic Step Down Charts were developed after the RBI Workshop.

Jan Gunlock

A SUMMARY OF NATURAL RESOURCE ISSUES

PHYSICAL GEOGRAPHY

The topography is derived from tectonic tension creating a north-south fault block mountain range and exposing limestones, shales, dolomites, and quartzites. The elevation in the park extends from the foothills at 6,200 feet to Wheeler Peak at 13,063 feet (the second highest peak in Nevada). A remnant glacier/rock glacier exists at the base of Wheeler Peak from what was one of the largest glaciers in the Great Basin. There are seven mountain peaks above 11,000 feet and another 13 above 10,000 feet. The South Snake Range slopes gradually toward the east and steeply toward the west.

Soil types, climate and vegetation are all vertically zoned. There is a wide diversity of types from alluvium to lithosols and tundra soils. Climate varies from middle latitude desert (5,000 to 6,500 feet) to alpine tundra (11,000 to 13,000 feet). The temperature ranges from a maximum of 85 degrees F to 95 degrees F during the summer in the valleys to 55 degrees F to 65 degrees F on the mountain ridges. The corresponding precipitation ranges from an average annual rainfall of 6 inches in the valleys to 20 - 30 inches on the mountain ridges. January temperatures at Lehman Caves (6,825 feet) may vary from -10 degrees F to 30 degrees F (average annual rainfall of 12.6 inches).

PARK DEVELOPMENT

Although little has changed to date except the name, the creation of the new national park has increased visitor use, rendering old NPS and USFS facilities inadequate for the public and park staff alike. Visitor facilities consist of an interpretive center, small concession cafe/gift shop, and four developed campgrounds with a total of 104 campsites. During the summer of 1987, the campgrounds usually filled by early afternoon. The Labor Day weekend crowd peaked at over 250 camping units per day, with numerous out-of-bounds campers. Cave tours during this same period increased from a standard seven per day (30 people/tour) to 17 per day. On holidays, the cave tours were usually sold-out for the entire day by 11:00 A.M. even with the extra tours. In 1988, the second year after the Park was created, visitor use totaled 75,128, which represents an 80.7 percent increase from the Lehman Caves National Monument visitation in 1986. During the same period the number of visitors on cave tours was 46,264 which is a 44.2 percent increase above 1986 cave tour use. Since then, annual visitor use in the Park has remained rather constant between 72,000 and 75,000.

There are two paved roads in the park amounting to about 15 miles—12 miles of this is the Wheeler Peak Scenic Drive beginning at 6,500 feet elevation and winding to over 10,000 feet. Many gravel or high clearance roads provide access into canyons and eventually link to backcountry trails.

Administrative facilities and staff housing includes offices in the Visitor Center, two maintenance buildings and yard, eight houses, two cabins and four mobile homes - all on about 15 acres. In 1988, two modular homes were added. Few, if any, houses are available for rental or purchase in Baker. NPS staffing has increased from a total of 20 employees at Lehman Caves National Monument to 55 employees at Great Basin National Park. Future support facilities for park operations, including housing, will be proposed by the GMP for the 80 acre Baker Ranger Station, an administrative site. Meanwhile, the NPS is renting 15 additional efficiency apartments for employees. Any development at the Baker Ranger Station land will require the construction of all utilities. The four campgrounds occupy approximately 92 acres, and they are all in riparian zones. Based upon public comment during the GMP scoping meetings, the public does not want much more development in the park. The mountainous terrain also limits development.

VEGETATION MANAGEMENT

Grazing, wildland fire management, and threatened and endangered species are the major vegetation management issues. Other management concerns are recognized: the restoration of disturbed sites, the control or eradication of alien (non-native) plants, and the re-establishment of an historic orchard. A vegetation map of the entire mountain range is being developed. It will be digitized for future Geographic Information System (GIS) computer analysis. Identified plant associations include: grass and big sage; grass and mixed shrubs; meadows; grasses and birch/willow; aspen; aspen and fir; pinyon/juniper; mountain mahogany; mahogany and pinyon; mixed conifer with Ponderosa pine, White fir, Douglas fir and Limber pine; grass and black sage; Englemann spruce; Limber pine and spruce; Limber and Bristlecone pine; Bristlecone pine and alpine tundra; and spruce in krummholz.

The need for site restoration stems from past mineral exploration and mining as well as old NPS/USFS development such as roads and trails. Alien species of concern are: cheat grass (*Bromus tectorum*), spotted knapweed (*Centaurea maculosa*), and white top (*Cardaria drabe*).

All that remains of the small Lehman orchard are a few peach and apricot trees that date back to the 1880's. In the early 1930's it still had apple and pear trees. This genetic stock is rare, if even commercially available today, and is being reproduced, before it is lost.

GRAZING MANAGEMENT

Great Basin National Park is charged through its enabling legislation to permit the grazing of livestock; "Subject to such limitations, conditions, or regulations as he may prescribe, the Secretary [of the Interior] shall permit grazing on lands within the park to the same extent as was permitted on such lands as of July 1, 1985." The legislative history which explains Section 3(e) of the Act states that grazing is an integral part of the history of the Great Basin and "...that grazing is to continue in the park subject to the constraints imposed by the Secretary [of the Interior] to ensure proper rangeland management practices."

Today, grazing occurs throughout the park wherever suitable range is present with the exception of 640 acres of the former Lehman Caves National Monument, where there was no grazing in 1985. While the total acreage for each allotment is quite large, much of this is unsuitable or unavailable for livestock grazing. The park is divided into seven allotments. Two cattle allotments are managed entirely by the park, two sheep and two cattle allotments are managed with the U.S. Forest Service (USFS), and one cattle allotment is managed with the U.S. Forest Service and Bureau of Land Management. There are 615 cattle and 3,100 sheep permitted to graze within the park from June 1 to October 10 of each year. Congress indicated its intention that the NPS manage grazing with policies and regulations compatible with those of the USFS.

Cattle distribution is regulated by topographic barriers and range developments, while sheep distribution is regulated by a herder. Potential livestock/visitor use conflicts include aesthetics, public health concerns, and competition for use of common use areas (campsites, riparian areas, and trails). Potential resource/livestock conflicts include sensitive natural resources (riparian zones, meadows, and alpine habitat), and vulnerable wildlife resources (communicable diseases from livestock pose an immediate threat to the Rocky Mountain bighorn sheep populations, estimated by the Nevada Department of Wildlife (NDOW) at 10-15 animals).

WILDLAND FIRE MANAGEMENT

The combination of grazing and an active fire suppression program in the past has encouraged plant succession toward the climax stage of woody plants with heavy fuel loading in some plant communities. Examples are dense curlleaf mountain mahogany stands with closed canopies (ages 100+ years), a large and expanding pinyon pine forest, and old age quaking aspen groves with encroachment by white fir and Englemann spruce. The natural fire frequency for mahogany in Nevada has been estimated as between 22 and 37 years. A fire history and fuels inventory is needed before developing a new Fire Management Plan and implementing a prescribed fire program. A vegetation map being developed for future computer application (GIS) will require further definition with transects and research plots to assess fire effects.

WATER RESOURCES

Ten permanent streams originate in the Park between 6,200 and 11,000 feet elevation and are fed by numerous springs along their courses. The streams average five miles in length. Five alpine lakes averaging three acres in size also exist, two of which support trout populations. Five streams flow eastward into Snake Valley, and five drain westward into Spring Valley. There are eight major drainages in the Park. The largest streams, Lehman and Baker Creeks, are in the Wheeler Peak area where the major Park development exists. They also supply domestic and irrigation water to those holding water rights in the town of Baker. Snake Creek, another large stream, contains a three mile long water diversion system in the park to avoid loss in a porous or karst section of the streambed enroute to the town of Garrison. Other stream diversions exist as well. Most of the streams gradually percolate into the alluvium and/or evaporate before reaching the adjacent valleys. Virtually all of the surface water originates in the Park where weather and rainfall have been monitored for 50 years and snowpack has been measured for 45 years.

WATER RIGHTS

Water rights are a critical issue in the arid western states - a fact reflected in the enabling legislation for the Park. Congress stated that no "new expressed or implied reservation to the United States of any water or water-related right" was created by the Act. The appropriation of water is subject to the laws of Nevada that recognize reserved water rights for recreation, and more recently, wildlife as well. As a result, the Park is currently limited to the amount of water stemming from earlier reserved rights for Lehman Caves National Monument and Humboldt National Forest and an appropriative right at Cave Spring. It is questionable whether these rights will provide sufficient water for future park development. Most claims to water date back to the early 1900's and occur outside the park, but the Nevada Division of Water Resources found 105 active water rights dependent upon the park watershed in the Baker and Lehman Drainages, alone. A three year study has been funded, beginning in FY-90, to evaluate these water rights, design a monitoring scheme for water quality and quantity, and develop a water resource management plan.

FISHERIES

Fishing is authorized in the enabling legislation in cooperation with the Nevada Department of Wildlife (NDOW). Fish stocking and recreational fishing have historically occurred in Lehman, Baker, and Snake Creeks plus two of the five alpine lakes - Baker and Johnson Lakes. NPS policy prohibits the artificial stocking of alien fishes in natural management zones, but allows it in special use zones when "exotic species are already present and established and where scientific data indicate" that native populations would not be seriously diminished.

Lehman and Baker Creeks were stocked at a rate of 750 fish per stream per month with Brown trout from June through August of each year prior to 1985 and with Rainbow trout in 1985 and 1986 (two months only in 1986). Snake Creek received 1,000 fish per month (June, July, and August) with Rainbow trout up until 1985. Johnson Lake has a self-sustaining Brook trout population and Baker Lake was restocked with cutthroat once every three years. The NPS and NDOW agreed not to stock any park streams in the furtherance of both agency's management policies.

The Bonneville cutthroat trout is a candidate species for threatened status, and is considered to be native to the Bonneville Basin of eastern Nevada and western Utah. They exist in Pine and Ridge Creeks which straddle the park boundary on the west side of the mountain range. NDOW proposes to augment this native population with introductions in the adjacent Shingle Creek. The South Fork of Big Wash Creek on the eastern slope has been identified as prime habitat. More restrictive fishing regulations may be necessary in streams with Bonneville cutthroat trout to provide adequate protection. It may also be desirable to re-establish beaver in selected streams to improve the fishery, but only if beaver are indeed endemic to the mountain range. Fisheries management alternatives need to be developed with NDOW for the General Management Plan.

WILDLIFE MANAGEMENT

Government agencies and the public have traditionally focused upon game species because of hunting and trapping interests. For the South Snake Range this included mule deer, Rocky Mountain bighorn sheep, mountain lion, bobcat, and coyote. While hunting and trapping are prohibited within the Park, these activities continue on the surrounding lands. Neighboring farmers fear crop damage from an over-populating

Jan Gunlock

deer herd, and ranchers predict increased predation on domestic livestock due to NPS policies protecting predators, although others point out that predators will help control the size of the deer herd. NDOW may need to develop different hunting and trapping seasons and bag limits around the Park to meet the situation, as it develops. More information is needed on the populations of these species as well as those of non-game species.

Rocky Mountain bighorn sheep were re-introduced to the mountain range by NDOW in the 1979-80 transplant of 30 animals from Colorado. They inhabit the southwestern alpine region of the range where domestic sheep also graze. The potential for debilitating diseases to be transmitted to the bighorn sheep population is high.

Elk were extirpated from Nevada by 1900, and re-introduced into the Schell Creek Range to the west of the Park in 1933. Today, they also exist in the Mountain Home Range to the southeast of the park, and transient individuals have been sighted in the South Snake Range. Re-introducing elk to the Park has been proposed, but potential disease and forage conflicts may exist with cattle. Unassisted re-establishment is considered likely.

THREATENED AND ENDANGERED SPECIES

The Park is potential habitat for the Bald eagle and Peregrine falcon. NPS and NDOW have begun re-introducing falcons in the Lincoln Canyon/Mt. Washington area. Candidate species for status as federally threatened and endangered, which either exist in the park or the park provides potential habitat, include the Bonneville cutthroat trout, Ferruginous hawk, and four plants (Cymopterus nivalis, Eriogonum holmgrenii, Penstemon concinnus, and Primula nevadensis).

These latter alpine plant species represent just a few of the rare and endemic plant species suspected to be in the Park. The most notable thing about threatened and endangered species is our lack of information about them. Field surveys for alpine plants, butterflies, and mollusks are being conducted by independent researchers. Amphibians deserve further attention as potential bioidicators of global climate change because their numbers are declining worldwide.

BACKCOUNTRY USE

There are 26 miles of maintained trails and another 24 miles of historic trails in varying degrees of disrepair. A future trail system with connecting loops, and perhaps a ridge trail, could easily involve a total of 60 miles. Today, backcountry use is largely unregulated - neither permits nor designated campsites exist. Popular backcountry camping areas such as Baker and Johnson Lakes, are littered with campfire rings from woodburning. The Bristlecone pine forest and Alpine Lakes Trail below Wheeler Peak receive heavy public use and will be recommended for day use only, to reduce impacts. In some instances, old mining roads are utilized as hiking trails creating aesthetic, steep grade, and erosion problems. Most of the trails follow drainages and are not connected to one another to form a trail network or system. Standardized signs are needed. Some of the more popular campsites are in environmentally sensitive areas. Public health standards for drinking water and sewage are not being met in some instances, nor are grazing livestock excluded from most springs or campsites.

CAVE MANAGEMENT

Lehman Caves is one of about 30 known limestone caverns within the boundaries of Great Basin National Park. Detailed information is lacking for many of the caves. Lehman Caves' unique formations and rich adornment of stalactites, stalagmites, shields and columns were responsible for it being established as a National Monument in 1922. Today, it receives the same increasing visitor use as the Park. Since the park was created, about 46,000 visitors per year took the hour and a half guided cave tour. When considering the sensitivity of cave formations and speleogenesis to changes in temperature, relative humidity, and light, at what point are visitor carrying capacities reached? This is especially true when considering speleothem breakage by visitors and the introduction of lint and litter. The growth of algae in the cave is an obvious problem now. How best to mitigate the impacts of algae, and what subterranean factors are critical for the continued existence of endemic cave creatures like the cave cricket and pseudo-scorpion? These questions and others require further research for prudent park management. Spelunking enjoys increasing popularity - where and to what extent should this recreational activity occur and still assure resource protection for more remote, wild caves?

Cypress Swamp

MINING

In the South Snake Range, tungsten and gold have been the highest yielding commodities while lesser amounts of silver, lead, zinc and copper have been extracted. Beryllium and feldspar are also present.

The enabling legislation closed the Park to mineral leasing and entry, subject to valid existing rights. There are ten mining districts and a marble quarry in the mountain range, but no active mining operations within the Park. Unpatented claims number about 220; most of these occur within eight claim groups in the Mt. Washington area. The remaining claims are in the Snake Creek drainage area of the Park. There are no patented mining claims within the Park boundary, but several occur just outside the park. Congress purposely excluded these mineral interests from the park as exemplified by the "keyhole" boundary in the Mt. Washington area. However, in many instances, the owners of these patented mining claims will have to abide by NPS regulations because the only access to their claims is through the Park, and they are therefore covered by 36 CFR Part 9A regulations.

AIR QUALITY

Most national parks established prior to the Clean Air Act of 1977 are afforded the greatest air quality protection with Class I airshed designation. Great Basin National Park is a Class II airshed, yet still enjoys the best air quality in the continental United States with visibility often extending 120+ miles (mean standard visual range). Only Congress or the State of Nevada can re-designate the Park to Class I. Scenic vistas are an integral part of interpreting the basin and range theme, particularly since the enabling legislation allows for NPS to assume a coordinating role for interagency interpretation of the Great Basin physiographic province. Its character is of vast expanses of high desert valleys interspersed with numerous north-south oriented mountain ranges. To lose that perception to air pollution would compromise the aesthetic values and interpretive message. The night sky is another example of the importance of excellent air quality to the integrity of the Park and visitor experience. As recently as 1986, Wheeler Peak was being proposed as a future site for a new observatory.

Visibility monitoring consisted of aiming a teleradiometer at four distant targets three times per day from June 1982 to June 1986. Since then, photographs have been taken and analyzed of the farthest target, Notch Peak, 43 miles away. The park's monitoring site is near Lehman Caves where a Fine Particulate Air Sampler was located from October 1982 to April 1986. The Park has had a National Acid Deposition Program monitoring station since May 1985. Radiation is not monitored, but the effects of past fallout from the Mercury Test Site should be evaluated.

EXTERNAL THREATS

Although the Park is one of the more remote areas in the national park system, it is not immune from mining activity, herbicide and insecticide use from adjacent farming, weapons testing facilities, a nuclear weapons test site, additional corridors for power transmission lines, and two proposed coal-fired power plants (one north of Ely and another northeast of Wells, Nevada). Gold and tungsten are being mined beyond the western boundary in the Osceola and Minerva areas. Since the Park was created, a mining firm has proposed to construct a beryllium mine and processing plant on USFS land in the Mt. Washington area.

GLOBAL CHANGE

Great Basin National park has been selected by the National Park Service as one of several core research areas representing twenty biogeographic regions in a national global change program. Both the Great Basin biogeographic region and the Park are likely to be very sensitive to change given their environmental characteristics of the convergence of three climatic systems, closed small hydrologic systems, pristine air quality, steep elevational gradients with narrow ecotones, basin and range island biogeography, and a variety of limestone caverns. The predicted rates of global change will surpass the past rates that caused significant ecological changes in the region. A wealth of paleoecological resources will give perspective to our understanding of global change.

Research will probably focus upon the Committee of Earth Sciences elements of Ecological Systems and Dynamics and Earth System History. An integrated global change research plan will be developed with the Park as the core research area for an interagency approach to provide variety of sites within regional transects.

THE TACTICAL STEP DOWN PROCESS

The first function of the RBI Workshop was to collect a bibliography of reference literature from each participant representing the current knowledge about the Great Basin physiographic region in their discipline. Participants were asked to develop these in advance to establish "What is known?", as specifically as possible to the South Snake Range. After an orientation to park management issues, participants received an overview of the park planning effort to develop a General Management Plan—a document giving management guidance for the next 10 to 20 years. A dialogue ensued between planners and researchers to define current knowledge about the natural resources and identify concerns. This accomplished the first two RBI Workshop objectives.

Using a blueprint for resource management tactical planning (Phenicie and Lyon, 1973), the Workshop participants identified elements and procedural steps, and arranged these in a logical sequence or step down diagram (chart) for solving natural resource problems. The process of identifying the problem, resolving it into discrete elements by deductive and inductive thinking, incorporating park planning and funding considerations, and writing project statements is inherent in these steps. This Step Down Chart required six to ten levels (steps) to create a natural resource tactical plan for resource management and research activities:

Step #1, Determine the Goal;
Step #2, Identify and Define the Components;
Step #3, Select Appropriate Action(s);
Step #4, Complete Inventories and Actively Manage Resources;
Step #5, Develop and Implement Plans;
Steps #6 and 7, Identify, Experiment, and Develop Techniques to Resolve Problems;
Step #8, Inventory Biotic and Abiotic Ecosystem Components and Human Uses/Impacts;
Steps #9 and 10, Determine Specific Resource Problems.

The first level used a clause from the enabling legislation as the primary goal. Next, the second level of elements was derived to accomplish this goal. Each element must withstand the test for validity using the conditional sentence:

If and only if ___, then ___.

The first blank of this sentence is the antecedent. The second is the conclusion. The second level elements constitute the antecedent and the primary objective is the conclusion. From the step down diagram, the respective sentences might read:

If and only if we conserve and protect the scenery, cultural and natural resources, plus provide for the public use and enjoyment, can we attain the stated goal or conclusion.

If the antecedent is complete, the conclusion is the consequence of the condition and the reasoning is valid and complete (Phenicie and Lyons, 1973). Before proceeding to another level in the step down diagram, the following questions must be answered:

(a) Have any essential items been inadvertently omitted?

(b) Of those items identified, are all actually essential to reach the objective or are some interesting but non-essential?

Of the four constituents in the second level, the RBI Workshop only defined the natural resource component in the step down diagram. This was intentional and reflects the biological sciences expertise of the participants. In organizing the Workshop, it was decided that our attention could not be divided among aesthetic, natural, cultural, and sociological concerns. The interests would simply be too diverse to manage well, nor could the NPS financially afford to assemble all the participants required.

The third level of the natural resource step down diagram defines "conserve and protect". If and only if the NPS inventories to determine past and present conditions, understands dynamics, and takes appropriate management action(s), will it achieve the second level objective. This same logical process continues to the fourth level and beyond.

In subsequent levels, each component is reduced to its constituent parts. As an analysis and planning tool, the graphic form of the step down process has several advantages:

(a) it simplifies concepts and technical review;
(b) it encourages a team effort among the disciplines and delineates responsibilities in solving complicated problems; and
(c) it is a persuasive summarizing document showing the stepwise progression of knowledge required to solve the problem or attain the objective. (Decision makers can clearly see what is involved.)

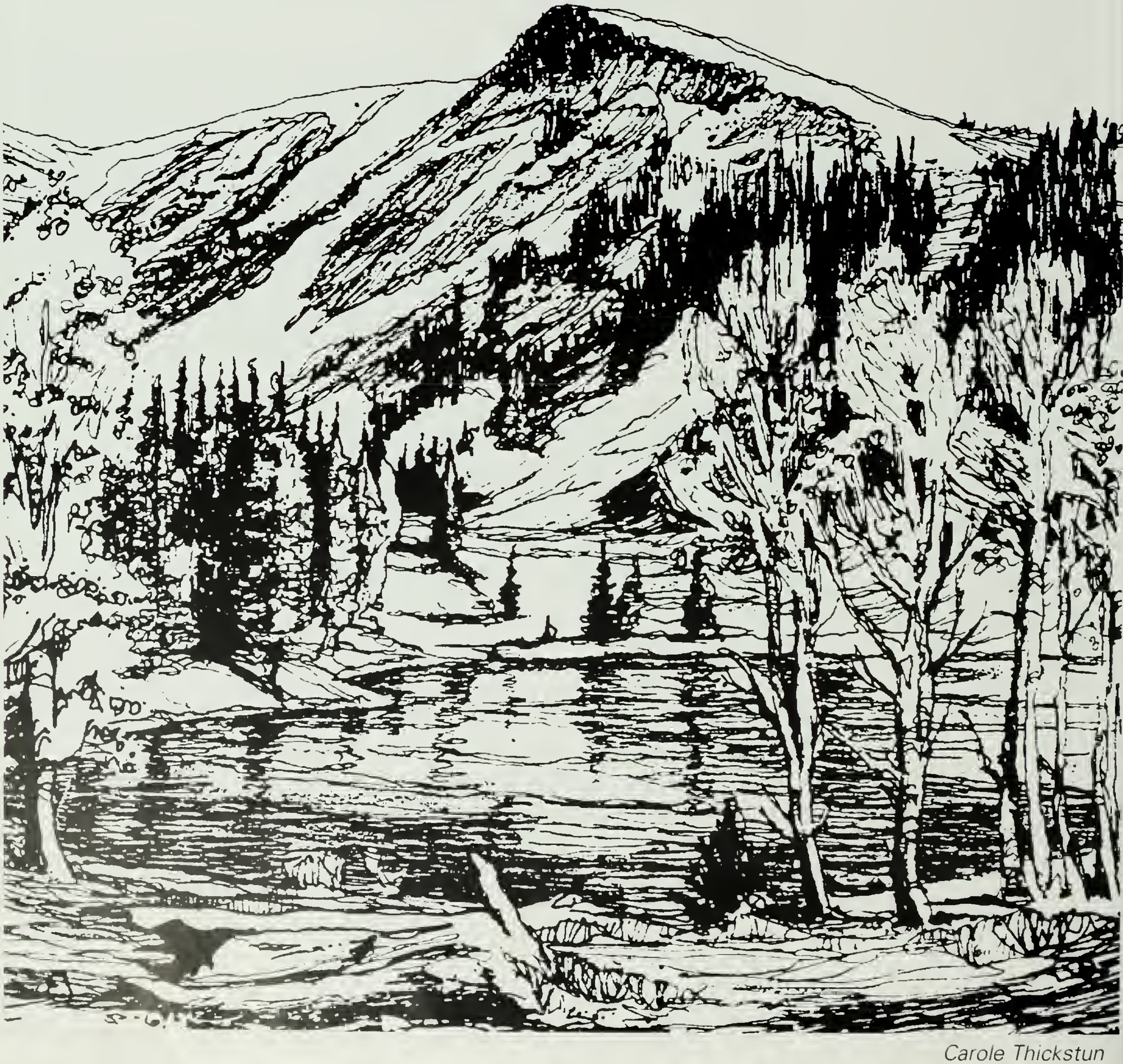
As the Step Down Chart evolved, the intensive reasoning and related discussions were an exhaustive process for the RBI workshop participants. Even with the multi-disciplinary attention that this tactical plan or chart received, further refinement was necessary for publication. Since the chart is a dynamic process, separate workshop sessions should be planned for the other constituents in the future. However, preliminary step down charts are included for cultural resources and socio-economic activities.

After the natural resource Step Down Chart was completed, the RBI Workshop divided into work groups by subject matter (vegetation, livestock and ungulate management, wildlife management, water resources, invertebrates, etc.) to develop project statements. The project statements adhered to an NPS format, and reflected the needs of a new park by focusing on baseline information at the bottom of the chart.

To aid in the understanding of how certain research and resource management actions relate to the Step Down Charts, references to the most applicable chart levels have been inserted within parentheses in the subsequent text. For example, the notation of (Level N-U 4 to 6) indicates that the research or resource management action corresponds to the **"Natural resource chart"** under the third level of

"Understand resource dynamics" and addresses the fourth to sixth levels of detail. Other abbreviations include cultural resources (C) and socio-economic values (S) for those Step Down Charts, plus inventory (I) and management (M) actions.

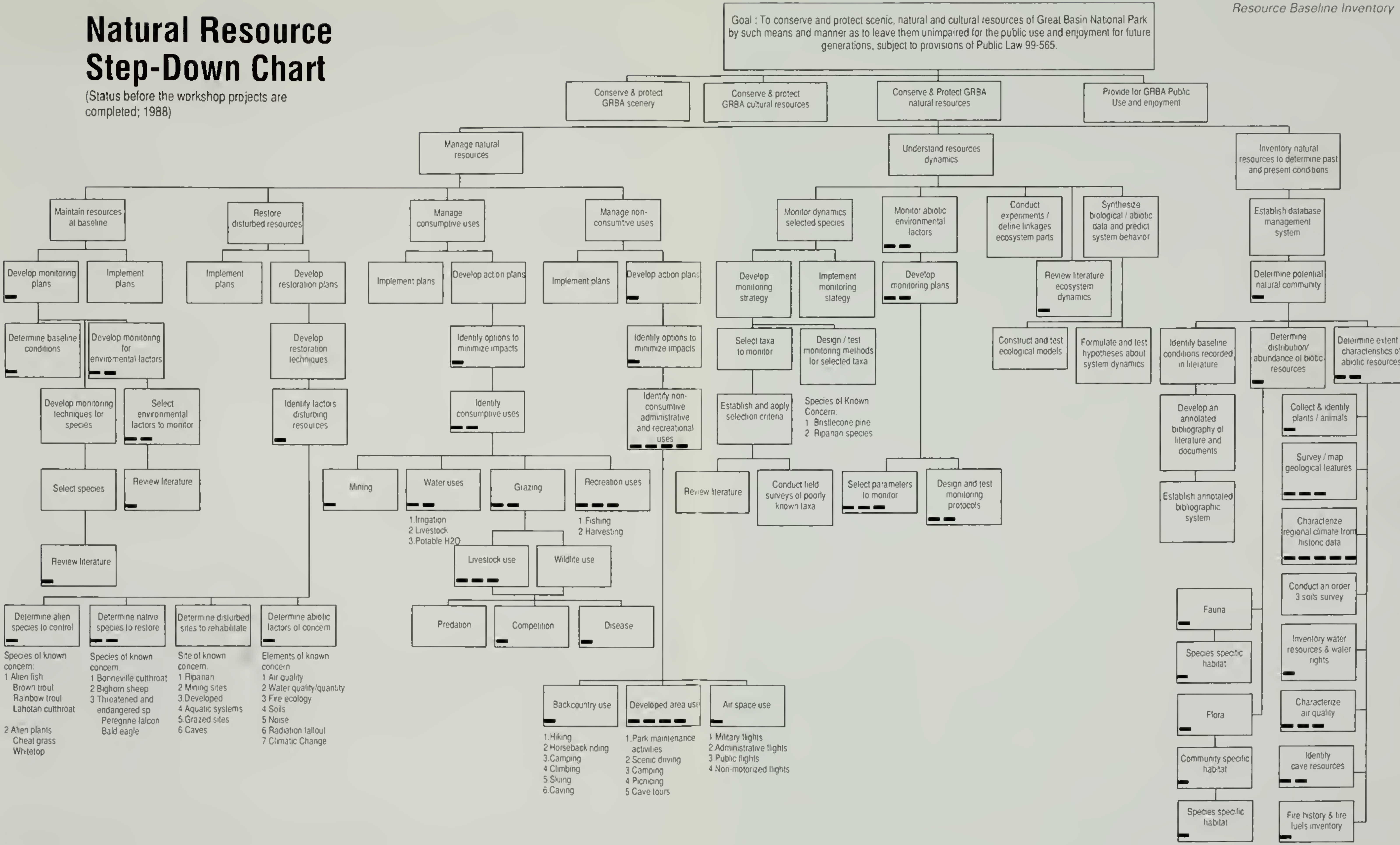
The Step Down Chart serves two other purposes besides summarizing the stepwise progression of knowledge required to solve a problem or attain an objective. First, it provides a general overview for evaluating research proposals or prioritizing project statements: Are we getting ahead of ourselves in the sense that the proposal seeks to fulfill needs somewhere within the center of the chart without sufficient baseline data?; Is a significant component(s) missing?; How does it coincide with Park objectives or contribute to future management decisions?; Is it significant enough that the Park should change priorities in order to assist with funding?; Where can particular research efforts be coordinated to avoid overlaps or voids? These are just a few of the questions that can be considered. Second, it allows scientists and managers alike to evaluate progress to date. By shading the chart boxes for the percent accomplished through several chart levels, progress and gaps in the information base become graphically apparent, even at increments of 20 percent.



Carole Thickstun

Natural Resource Step-Down Chart

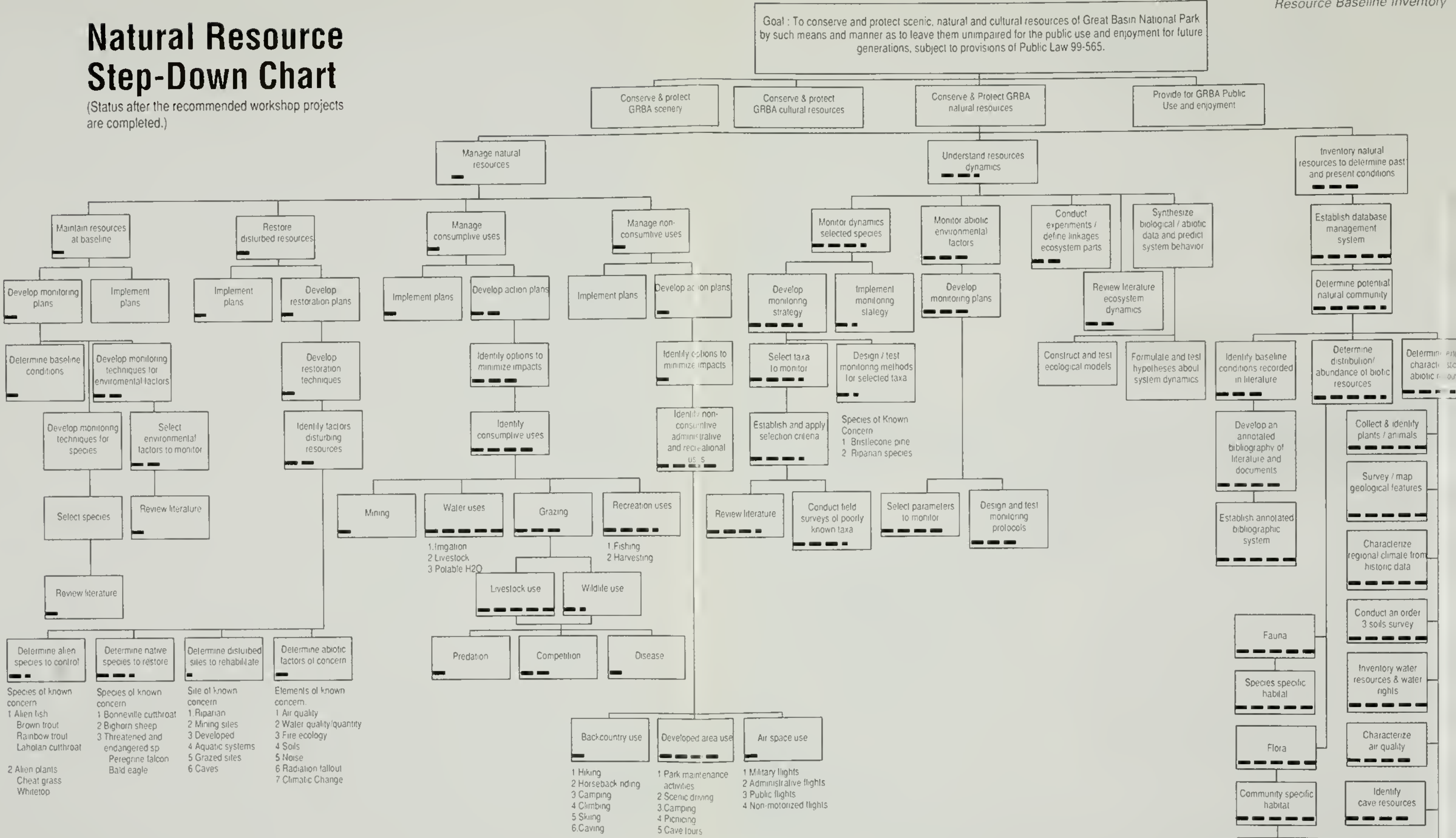
(Status before the workshop projects are completed; 1988)



Key
Each rectangle represents approximately 20% of work completed

Natural Resource Step-Down Chart

(Status after the recommended workshop projects are completed.)



Key

- Each rectangle represents approximately 10% of work completed
- Each rectangle represents approximately 20% of work completed

PROJECT STATEMENTS

Priority	Title	Recommended Action	Years Required			Total Cost
1.	Develop a Range Management Plan. Levels N-M5-10, Levels N-U4-8, Levels N-I3-7	Research vegetation classification and map for GIS; investigate dynamics, especially the effects of grazing, climate, and fire; examine visitor/livestock & livestocktwildlife conflicts; develop a monitoring system; write a Range Management Plan.	FY-1 $147K	FY-2 $26K	FY-3 $77K	$250
2.	Vegetation Classification, Description and Mapping. Levels N-U3-6, Levels N-I3-6	Complete the vegetation mapping and classification begun by the range management research, especially sensitive communities such as riparian and alpine or relict populations; and conduct a quantitative analysis of each communitiy type (including basin types outside the Park) using biotic and abiotic descriptors.	FY-1 $22.5K	FY-2 $21.5K		$44K
3.	Inventory of Vascular Flora. Levels N-I4-7	Inventory the vascular flora within the Park and encompass all growing seasons; describe species habitat by substrate, elevational range, and occurrence within community type; review existing literature and herbaria collections; identify endemic, threatened and endemic species; and prepare data for GIS vegetation map.	FY-1 $24.5K	FY-2 $25.5K		$50K
4.	Inventory & Assessment of the Use of Water & the Status of Water Rights held by others. Levels N-I5-6, Levels N-M5-8	Inventory existing water sources, developments, uses and needs; examine potential means for NPS to acquire water rights to satisfy park management requirements; and develop a water resources plan. (Part I for the Lehman and Baker Creek drainages was done by the NPS Water Resources Branch in 1988.)	FY-1 $22K	FY-2 $22K (for plan only)	FY-3 $22K	$66K
5.	Inventory of the Hydrological Resources. Levels N-I4-6	Review inventory of existing water sources, install measuring instruments on selected streams and springs, and monitor for several years.	This project will cost $25,000 per monitoring station for installation and $8,000 per station per year to operate.			
6.	Inventory & Assessment of Soil Resources. Levels N-I4-6	Survey the Park and certain drainages outside the Park at a level 2 soil analysis and digitize for GIS computer use; identify disturbed sites and high use areas; provide detailed soils information; and develop a soils map.	FY-1 $100K	FY-2 $75K	FY-3 $125K	$300K
7.	Inventory & Assessment of Geological Resources. Levels N-I4-6	Complete the geological survey for the South Snake Range and Park so the geology can be digitized for GIS computer analysis as a fundamental database.	FY-1 $15K	FY-2 $15K		$30K
8.	Monitoring Air Quality. Levels N-U3-6, Levels N-I3-6	Determine the potental for external impacts; analyze past NPS monitoring data; conduct a literature review; establish criteria pollutants to monitor including radiation.	FY-1 $5K	FY-2 $30K	FY-3 $10K	$45K
9.	Cave Inventory & Classification. Levels N-I3 to 6, Levels N-U3-6	Inventory known caves; classify caves according to resource values (including formation types), potential for impacts, difficulty of access, and extent of known information; review maps and literature; map selected caves; conduct a basic survey of biota; establish priorities for future research and exploration; and mitigate impacts in Lehman Caves.	FY-1 $30K	FY-2 $45K	FY-3 $45K	$120K
10.	Restoring Fire to Ecosystems. Levels N-U3-6, Levels N-I3-6	Conduct a fire history and fire fuels analysis, especially in the Engelmann spruce, aspen/fir, mountain mahogany, pinyon-juniper, and sage/grass communities; review existing literature and photography; and delineate fuel models on the GIS vegetation map. (This research will provide the basis for a future Fire Management Plan.)	FY-1 $1K	FY-2 $20K	FY-3 $20K	$41K

11.	Survey of Aquatic & Terrestrial Invertebrates. Levels N-I4-7, Levels N-Ur-8	Survey aquatic and terrestrial invertebrate fauna using standard qualitative and quantitative sampling procedures; identify taxa, locality, and habitat type; select index species and methodology for future monitoring; review existing literature and museum collections; and determine and map distribution for GIS analysis.	FY-1 $48K	FY-2 $48K	FY-3 $48K	$144K
12.	Inventory of Stream Fish Populations & Stream Habitat. Levels N-I4-7	Determine the species and distribution of fishes; map stream habitats using GIS standards; document livestock impacts on streams and recommend mitigation; conduct a literature review; and write a cooperative fisheries management plan for NPS and NDOW.	FY-1 $50K	FY-2 $25K		$75K
13.	Inventory of Non-vascular Flora. Levels N-I4-7	Inventory the non-vascular flora of the Park and encompass all growing seasons; describe species habitat by substrate, elevational range, and occurrence within community type; review existing literature and herbaria collections; identify endemic, threatened and endangered species; and prepare data for the GIS vegetation map.	FY-1 $21K	FY-2 $21K		$42K
14.	Inventory of the Avifauna. Levels N-I4-7, Levels N-U4-8	Research will use a series of census techniques to determine densities and distribution per vegetation type; develop a monitoring methodology; map habitats using GIS standards; and conduct a literature review.	FY-1 $30.7K	FY-2 $30.7K	FY-3 $28.6K	$90K
15.	Development of a Monitoring Plan for Deer Summer Range. Levels N-U4-8	Understand the interrelationships between deer, climate, and forage; research migration patterns and population dynamics; develop a long-term monitoring system.	FY-1 $30.2K FY-4 $21.6K	FY-2 $21.6K FY-5 $21.6K	FY-3 $21.6K	$116K
16.	Ecology of Bighorn Sheep (Rocky Mtn). Levels N-U4-8	Research the spatial distribution of both domestic and wild sheep, disease, and potential forage competition to reduce the opportunities for conflict; develop a strategy for maintaining a viable population of Rocky Mountain Bighorn Sheep.	FY-1 $35K	FY-2 $35K		$70K
17.	Rocky Mtn. Elk Mgmt. strategy. Levels N-U4-8	Determine the potential for elk to establish a viable population in the South Snake Range by immigration, its carrying capacity, and suggested methods of minimizing environmental impacts and conflicts with livestock and neighboring ranchers.	FY-1 $20K	FY-2 $20K		$40K
18.	Inventory of Mammals. Levels N-I3-7	Determine the species and distribution of mammals; map habitats using GIS standards; conduct a literature review and survey of museum collections.	FY-1 $21K	FY-2 $21K	FY-3 $21K	$63K
19.	Survey of the Herpetofauna. Levels N-I4-7, Levels N-U4-8	Determine the species and distribution of reptiles and amphibians; map habitats using GIS standards; determine the population density of selected species; conduct a literature review and survey of museum collections.	FY-1 $8K	FY-2 $8K	FY-3 $8K	$24K
20.	Eradication of Non-Native Salmonids & the Reintroduction of Native Salmonids. Levels N-M3-8	Evaluate the potential for reintroducing Bonneville Cutthroat Trout to east slope streams: hydrological data, eradication of alien salmonids, ability to maintain genetically pure populations, ability to support a recreational fishery, and public opinion: Strawberry Creek, South Fork of Big Wash, and perhaps Baker Creek.	FY-1 $5K FY-4 $5K	FY-2 $5K FY-5 $5K	FY-3 $5K	$25K
21.	Peregrine Falcon Reintroduction. Levels N-M3-8	Reintroduce the Peregrine falcon to the South Snake Range: locate a suitable hack site, release three to four birds per year for three consecutive years, supplement feed fledglings, use radio telemetry, and monitor returning birds to evaluate project success.	FY-1 $7.5K	FY-2 $7.5K	FY-3 $7.5K	$22.5K

A RESEARCH PERSPECTIVE: PAST INVESTIGATIONS AND FUTURE OPPORTUNITIES

In 1967, Dr. Paul T. Tueller of the University of Nevada, Reno (UNR) campus, chaired an ad hoc faculty committee to evaluate the research possibilities of the Snake Range. (Great Basin National Park was created in the South Snake Range on October 27, 1986.) The following discussion compares the conclusions reached by the UNR faculty committee with those of the RBI Workshop held at the University of Nevada, Las Vegas in January, 1988. The focus is on similarities since many of the differences merely reflect new technologies and an emphasis placed upon inventories by National Park Service policy. This discussion is intended as merely an overview to encourage further research and ultimately improved resource management.

ABIOTIC RESOURCES

Geologic Features

The UNR committee envisioned geologic research as taking a supportive role in interdisciplinary studies. They recognized some unique Great Basin physiographic features in the South Snake Range: above normal elevations; numerous limestone caverns; Pleistocene glacial features; and a rock glacier. The range has the characteristic northerly trending block faulting of uplifted mountain ranges with adjacent alluvium filled valleys. Bedrock geology involves Cambrian to Pennsylvanian quartzite, shale, and carbonate rocks. Minerals claims are primarily in the Mt. Washington area and contain tungsten and beryllium.

The RBI Workshop participants recommended an inventory of geologic and soil resources. An inventory and assessment of at least 30 known caves in the Park warranted the highest priority (*Levels N-I 4, 5, & 6*) in this category followed by the completion of the geologic map for the northern portion of the South Snake Range (*Levels N-I 4, 5, & 6*), the creation of Order 3 soils survey map (*Levels N-I 4, 5, & 6*), and an assessment of the glacier/rock glacier in the Wheeler Peak cirque (*Levels N-I 5 & 6*).

Future funding exists for a preliminary cave inventory and classification study. Similar RBI funding is also available to complete and digitize the geology map. The Soil Conservation Service has begun the soils survey and should complete it in 1992. Dr. Gerald Osborn of the University of Calgary, Canada, is currently conducting an independent study of the Wheeler Peak glacier/rock glacier. During the "Tahoe Glaciation", some 65,000 years ago, the glacier attained its farthest extension; to an elevation of 8,600 feet in the Lehman Creek drainage (Fullerton 1986). Today, it has receded to the peak cirque at 11,200 feet in elevation and has changed little since it was first described by the U.S. Geological Survey (Russell 1885). However, portions of the glacier may have thinned in the past 30 to 40 years (Osborn 1990).

The Geographic Information System (GIS) Branch of the NPS has digitized the mountain range and valley topography (1:250,000) for computer analysis, but desires 1:24,000 scale from U.S. Geological Survey for more detail. Digitized geology and soils maps will enable further analysis and refinement of the existing vegetation map, and serves as just one example of the interdisciplinary application of GIS.

Climatic Characteristics

The Great Basin physiographic region lies at the convergence of Pacific, Continental, and Gulf atmospheric circulation systems. Movement of these systems affects local and regional climate and is reflected by changes in hydrology and vegetation. Displacement of winter and summer stormtracks and penetration of the summer monsoon are all affected by the realignment of these pressure systems (Wharton et al, in press).

The park has a long-term record of basic weather observations at Lehman Caves beginning in 1937. The station is located at 6,825 feet on the east slope of the South Snake Range. John W. James, the State Climatologist, recently completed a climatological summary for the Lehman Caves weather station. The data indicate that the station is within the thermal belt on the mountain range with cooler days and warmer nights than the adjacent valleys in the summer. For example, July and August days average only about 84 degrees F, with just ten days per year reaching 90 degrees F or higher. Summer nights normally average in the mid-50's. A similar diurnal pattern occurs in the winter with nightly lows averaging 18 to 20 degrees F from December to February and only four days per year reaching zero or below.

The climate in the Park is semi-arid with about 13 inches of annual precipitation which is rather evenly distributed throughout the year. Spring tends to be slightly wetter as Pacific storms sometime become "Great Basin Lows," making for very unstable "upslope conditions" in the Snake Range. Winter storms (November to April) move toward the mountain range from the Pacific which places it in a rain/snow shadow; however, Lehman Caves averages 6 feet of snow per year. Snowfall is probably one-third as much in the Snake Valley below, but at least four times as much falls above 10,000 feet in the Snake Range. During summer's "Arizona Monsoon" thunderstorm season, moisture reaches eastern Nevada and Utah from the southeast Gulf atmospheric circulation system. The park averages 30 thunderstorms per year.

The UNR committee regarded the Snake Range, and Wheeler Peak specifically, as an ideal location for field studies in mountain meteorology because of the valley to peak altitude variation, geographic position midway between the Sierra Nevada and Rocky Mountains, and the proximity to the 12-hourly radiosonde observations in Ely, Nevada. Other advantages include outstanding air quality, mountain summits frequently cloud covered for *in situ* cloud particle measurements, sufficient snowfall in the winter to study the orographic effects on deposition, and frequent convective activity in the summer for observations of cloud growth and thunderstorm phenomena. They proposed twelve research projects including rates of snow melt and runoff for water supply forecasts, micro-meteorological measurements of temperature at different elevations for ecological studies, chemical analysis of snow deposition, meso-scale observations of the effects of the Snake Range on air flow, cloud growth and precipitation, and automatic weather stations for telemetry of basic data from mountain peaks.

The RBI Workshop recognized the importance of climatic studies in the Step Down Chart and to monitoring global change. The current range management research is using remote weather stations to investigate the effects of climate on metabolism of selected plants. As an interpretive tool to illustrate the altitudinal difference in at least wind speed and temperature (i.e. chill factor), the NPS is interested in establishing a telemetry weather station on or near Wheeler Peak. The digital read-out would be in the Park Visitor Center and compare Wheeler Peak (13,063 ft.) with Lehman Caves (6,825 ft.). There is also interest in establishing a series of remote weather stations from the valleys to the peaks to answer some questions raised by the UNR Committee (*Levels N-I 4, 5, & 6*).

The climatic factors which make the Park a valuable natural laboratory for understanding global change include:

1) low annual precipitation (plant stress, hydrologic processes and many other environmental factors are controlled by the lack of precipitation;
2) shallow, alpine lakes and streams range from sensitive to ultra-sensitive to acid deposition;
3) strong precipitation gradients correspond to elevation changes from 7 inches in the basins to 35 inches on the mountain peaks within a distance of a few miles.
4) strong elevational stratification of other meteorological variables;
5) high frequency of clear skies, low source strengths of local pollutants, low humidity, large incoming solar and photosynthetically active radiation flux, and large outgoing infrared flux;
6) high rates of evaporation and evapotranspiration; and
7) sensitivity to air and cloud pollution, aerosol increases, and dust transport.

Hydrological Resources

The Great Basin region has been categorized as hydrologically the most sensitive region in the United States to global climate change (Maggs 1989, Schneider 1988). Like most Great Basin mountains, the South Snake Range is on a north-south axis with the watershed draining into two semi-arid basins, Snake and Spring valleys. There are ten perennial streams, five alpine lakes, and numerous springs in the Park. Most of the surface flow on the alluvial slopes is lost by percolation and evaporation. Several water diversion systems exist outside the Park to conserve water for agricultural fields in the adjacent valleys.

The UNR Committee cited stream flow measurements and a study of interbasin underflow of ground water through carbonate rock. They found the mountain peaks to produce less runoff than expected, and felt that the eastward dipping limestone bedrock underlying the entire area was responsible for transporting more water to Snake Valley. Highly permeable, eastward fault zones contributed to lower elevation spring discharge.

Their suggested research projects were studies of springs and underground flow patterns and evaporation at various elevations relative to the storage of water in lakes (*Level N-U 4*). To aid in accomplishing this, they were interested in extending the snow courses, installing remote recording equipment, and measuring snowpack temperature and density (*Levels N-U 4-6*).

There is a 46 year record for the three snow courses in the Baker Creek drainage, located at elevations of 7,950, 8,950 and 9,250 feet. The average yearly snow depth and snow water equivalent (swe) taken at snow course #2 (8,950') is 50 inches of snow and 15.7 inches of water. The snow depth extremes were 86 inches with 36.6 inches swe in 1952, and a minimum of 20 inches depth and 4.6 inches swe in 1977. Based upon studies in 1965 (Rush & Kasmi, 1965; Hood & Rush, 1965) of the larger creeks in the South Snake Range, Baker Creek had an annual flow of 6,200 acre-feet and Lehman Creek had an annual flow of 5,400 acre-feet. Snowpack melt accounted for peak flows during May, June, and July.

Based upon the Step Down Chart and the need to determine water rights, the National Park Service has taken a two-pronged approach to the hydrological question. The first questions confronting park management were related to water rights (*Level N-I 6*). In establishing the Park, Congress limited Federal reserved rights to those associated with Lehman Caves National Monument and Humboldt National Forest. These rights are probably not sufficient to support present and future park visitor use, and do not include the four developed campgrounds. This, and related legal questions, need to be resolved in the future. In 1988, the Water Resources Division of NPS completed a "Hydrologic Characterization and Inventory of Water Rights, Uses and Requirements at Great Basin National Park, Nevada: Part I - Baker and Lehman Creek Basins".

The second question dealt with water quality. During the winter and spring of 1989 three scientists from Lockheed Engineering and Sciences Company under contract with the U.S. Environmental Protection Agency (EPA) surveyed selected streams and lakes in the Park to measure pH, conductivity, dissolved oxygen, oxidation reduction potential, an array of elements, and determine the acid neutralizing capacity (Metcalf, et. al. 1989)(*Levels N-U 4-6,* & I 5&6). Strict quality assurance procedures were adhered to in the field and laboratory. The sensitivity of aquatic ecosystems to acidification, sulfate and nitrate deposition, is measured by their acid neutralizing capacity (ANC). Using the U.S. Forest Service Region 4 Acidification Sensitivity Index and EPA National Surface Water Survey, all of the alpine lakes and at least one stream surveyed to date are sensitive to ultrasensitive:

Alkalinity less than 200 μeq/liter = sensitive
Alkalinity less than 125 μeq/liter = very sensitive
Alkalinity less than 75 μeq/liter = ultrasensitive

The entire Baker Lake drainage is very sensitive with the lake itself being ultrasensitive. This low buffering capacity indicates that the hydrological systems in the Park have little protection from acid deposition by rain, snow, fog, or dry fallout. High elevation watersheds are particularly susceptible and sensitive to acid deposition because of their thin soils and sparse vegetation. This sensitivity is accentuated because the alpine zone of the South Snake Range is primarily composed of granitic rock.

Location	Elevation	ANC
Baker Creek	8,000 ft.	111 μeq/liter
Bakei Lake	10,620 ft.	73.2 "
Brown Lake	10,180 ft.	110 "
Dead Lake	9,480 ft.	144 "
Johnson Lake	10,760 ft.	164 "
Stella Lake	10,380 ft.	197 "
Teresa Lake	10,260 ft.	105 "

(Measurements taken May 20 to 23, 1989; Metcalf, et. al. 1989)

Lake acid neutralizing capacity (ANC) is one sensitive indicator of air quality related values (AQRV's) for the Park (Levels N-U 4 to 6). Soil pH is another important sensitive indicator. The acid deposition precursors (SO_2 and NO_x) are suspected to be increasing from long range westerly wind transport. Further inventory and monitoring is required to establish baseline conditions, detect acid deposition trends, and determine related environmental impacts. Besides monitoring lake alkalinity and visibility as AQRV indicators, sensitive biological indicators such as aquatic invertebrates and lichens deserve examination. Limits of Acceptable Change (LAC) (Stankey et al 1985) should be established and annual monitoring reports submitted to the Nevada Division of Environmental Protection, Air Quality Section.

By applying the measured non-marine base cation sum (Ca+Mg+K+Na) obtained by the Lockheed Engineering and Sciences Company scientists for the Baker Lake/Creek watershed to the air pollution screening model developed by the U.S. Forest Service, Rocky Mountain Forest and Range Experimental Station, the results are 4.8 to 7.6 kg S/ha/yr and 7.4 to 10.6 kg S/ha/yr (Baker Lake, 108 μeq/l and Baker Creek, 156 μeq/l) for Green and Red Line (acceptable verses unacceptable) deposition loading, respectively, (Fox et.al. 1989). This assumes an adjustment for marine influence, that the dry deposition is negligible, and that the runoff is between 40 to 50 percent of precipitation. The screening model was designed as a general guideline to assist scientists and managers in evaluating the potential impact of any proposed air pollution sources on Class I wilderness areas. (The Park is currently a Class II airshed which provides less environmental protection than Class I.) Pollutant doses less than the Green Line value might be permissible, while doses above the Red Line value are likely to cause at least one AQRV to be adversely affected. This provides an initial estimate of susceptibility to critical loadings for sulfur, nitrogen, and ozone. Since this study focused upon selected streams and lakes, there may be more watersheds of a sensitive nature which were not sampled in 1989.

Using the 1986 to 1988 data from the National Atmospheric Deposition Program/ National Trends Network (NADP/NTN) for the Lehman Caves monitoring site, the three year precipitation-weighted mean sulfate concentration is 0.77 milligrams per liter (mg/l). Average wet deposition is 0.80 kg S/ha/yr. The average percentile-90 sulfate concentration is 2.49 mg/l. This equates to an extreme case wet deposition estimate of 2.58 kg S/ha/yr, (Levels N-I 5 & 6). (If it is assumed that the wet equals the dry deposition, the total sulfur deposition would be within the Yellow Zone (caution, impacts may be occurring) of the screening model for Baker Lake and require further evaluation.) Both the current wet deposition and the percentile-90 values are below the Green Line value of the air pollution screening model indicating a low probability of deleterious impacts. Thus, according to the model, the current annual precipitation does not contain sufficient acid deposition to environmentally impact the very sensitive Baker Creek watershed, unless it is occurring as acid shock during snowmelt.

Acidification of streams and lakes can have two major adverse effects on aquatic ecosystems: acid shock during snowmelt and long-term pH changes causing mortality or declines in reproduction, growth, and biodiversity of plankton, invertebrates, and vertebrate species. For snowmelt, it should be considered that 50 to 80 percent of the pollutant load is released with the first 30 percent of the melt water. (Johannessen, et. al. 1978) Long-term acidification thresholds can be expected to be low for total SO_2 and NO_x deposition. The Lockheed scientists recommended that a cost-effective, practical monitoring strategy be developed for representative streams and lakes using quality-assured pH data and semi-annual conductivity surveys. They developed a simple linear regression between conductivity and acid neutralizing capacity (ANC) to allow for inexpensive monitoring in the spring and fall of each year. If gradual acidification is detected, more intensive chemical monitoring should occur and mitigating action(s) be considered by air pollution sources to avoid significant degradation from present conditions.

Beginning in 1990, the NPS will fund three years of research and planning to develop a Water Resources Management Plan. If possible, this project should inventory aquatic fauna, determine bioindicators of change with a monitoring strategy, develop a strategy for monitoring water quality and quantity, suggest mitigating measures for livestock grazing and mining operations, impacts, and minimize NPS water requirements for future Park operations.

Air Quality Characteristics

The subject of air quality was not examined by the UNR Committee, but visibility monitoring has been conducted at Lehman Caves since 1981 and fine particulate monitoring occurred between 1982 and 1986. Acid rain deposition has been monitored since 1985. Great Basin National Park is a Class II airshed under the Clean Air Act of 1977, but deserves further consideration for greater protection of its relatively pristine air quality. To aid in protecting these air quality related values (AQRV), more sophisticated and accurate monitoring should occur (*Levels N-U 4-6*). The AQRV's include flora, fauna, soil, water, and air (odor, visibility, acid rain deposition, and fine particulates). Sensitive indicators for monitoring could include soil pH, lichens for flora, aquatic insects for fauna, alpine lake alkalinity for water, and visual range and fine particulates for air.

Today, scenic vistas at all NPS monitoring sites are affected by manmade air pollution more than 90 percent of the time. However, the best visibility at monitored NPS units across the nation exists in eastern Oregon, eastern Nevada, western Utah, and southern Idaho — the Great Basin clear air corridor. The Standard Visual Range (SVR) varies by season at the 90 percent cumulative frequency, but is consistently more than 186 miles (300 km.) and occasionally above 230 miles (370 km.).

Scenic vistas assume a new dimension at Great Basin N.P. because it is one of the nation's best sites for viewing the stars. Dr. Roger Lunds and Dr. Jean Good of the Kitt Peak National Observatory chose Wheeler Peak (13,063 ft), before the Park was created, as their first choice for a new national observatory site. Their 1984 study of 56 mountain peaks in five western states favored Wheeler Peak because of its unusually clear skies, cool dry air, light-free night sky, and minimal air turbulence. These astronomical qualities are a significant part of the Park's natural resources. Evening campground programs during the summer interpret the night sky to park visitors using a portable telescope and sky map of the constellations. The Wheeler Peak campground (9,950 ft) is a prime location for this unique star gazing opportunity.

Total suspended particulates (diameter less than 10 microns) is generally responsible for a major portion of visibility impairment. Of these, sulfate particles (primarily a result of the chemical transformation of manmade sulfur oxide emissions) are the single most important contributor to visibility impairment in NPS units. The average seasonal sulfate concentrations at the Park vary from 99 ng/m^3 (nanogram per cubic meter) in the winter to 260 ng/m^3 in the summer. The table below compares the average concentrations in ng/m^3 for all 30 NPS Class I particulate monitoring sites with the concentrations monitored at Great Basin N.P. during the winter of 1986: (see Table 1)

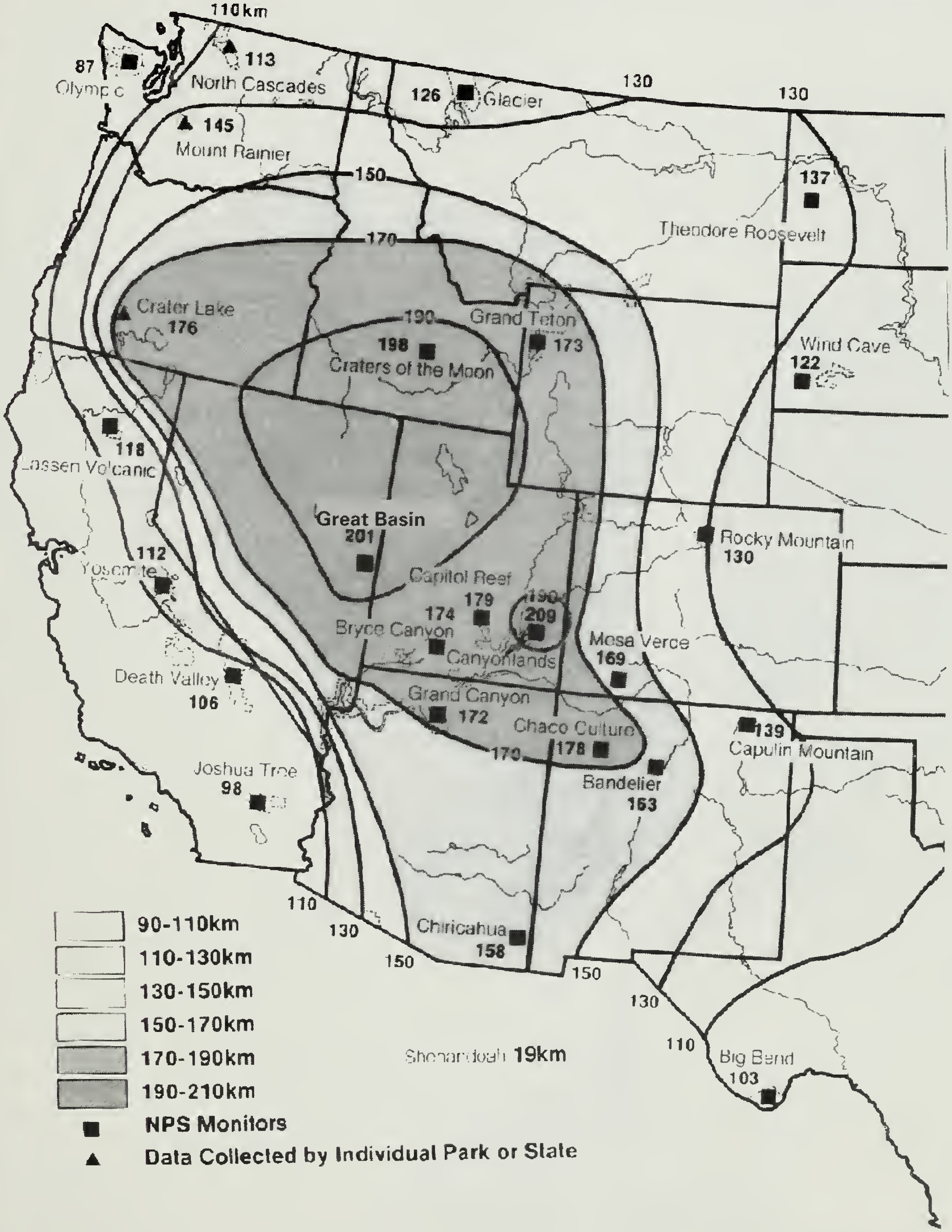
Ozone, a national criteria pollutant, is generally accepted as the most widespread air pollutant. It is apparently responsible for foliar injury in many NPS units [at concentrations lower than the National Ambient Air Quality Standards (NAAQS)], but it has never been monitored at Great Basin N.P. To obtain a regional perspective of ozone concentrations, we can examine the second highest hourly concentrations μg/m^3 in 1988 at several Class I NPS units surrounding the Park compared to some nonattainment western cities:

Arches N.P., UT	— 0.068 (0)	μg/m^3
Lassen Volcanic N.P., CA	— 0.082 (0)	"
Petrified Forest N.P., AZ	— 0.068 (0)	"
Sequoia N.P., CA	— 0.121 (0)	"
Yellowstone N.P., WY	— 0.090 (0)	"
Yosemite N.P., CA	— 0.113 (0)	"
Los Angeles, CA	— 0.330 (148)	μg/m^3
Reno, NV	— 0.109 (5)	"
Salt Lake City, UT	— 0.143 (2)	"
San Francisco, CA	— 0.140 (4)	"

(number of days with hourly concentrations over NAAQS of 0.12 ppm)(NPS, 1989)

Radioactive fallout from the Mercury Test Site occurred in the area during the 1950's, and the residual amount and biological effects deserve examination.

ISOPLETHS OF MEDIAN VISUAL RANGE OVER THE WESTERN UNITED STATES, SUMMER 1983



BIOTIC RESOURCES

Vascular and Non-vascular Botany

The UNR committee considered the Snake Range unknown and unexplored botanically in 1967. Taxonomy, phytogeography, speciation, ecology, and adaptations were of particular interest. They felt that colonizers of limited mobility could establish themselves in the Snake Range from the Rocky Mountains, Sierra Nevada, or elsewhere in the Great Basin. The variety of terrain and substrates were regarded as favorable for speciation, especially since this mountain range was midway between the Rocky Mountain and Sierra Nevada Ranges. Studies of vegetation and flora in the Snake Range seemed important for an understanding of Great Basin ecology and phytogeography.

The RBI Workshop participants recognized these same research needs and also noted some threatened and Category II species under the Endangered Species Act. Several species reach the edge of their distribution from either the Rocky Mountain or Sierra Nevada Ranges. The RBI Workshop felt more basic information was required, and asked for separate inventories of vascular and non-vascular flora as well as mapping vegetation and determining floristic composition. With approximately 70 years of wildland fire suppression in the Snake Range, they recommended an ecological study of fire and an eventual restoration of its role. (There is a particularly interesting 20 acre burn in the Mt. Washington bristlecone pine forest which occurred sometime prior to 1967.)

In 1967, bristlecone pine, _Pinus longaeva_, was inventoried in three major groves (Wheeler Peak, Mt. Washington, and Peak 10,842) which comprise a total of 775 acres (Klemmedson and Beasley, 1967). Portions of the Mt. Washington grove were so significant that the U.S. Forest Service recommended establishing a Research Natural Area which the NPS will propose to expand in its draft General Management Plan. These groves and other smaller ones of ancient trees range in elevation from 9,800 ft. to 11,200 ft. With the exception of Wheeler Peak, they occur on limestone soils with a south or west aspect. By contrast, the Wheeler Peak grove is uniquely located on moraines of quartzite with a northeastern exposure. In 1964, a 4,950 year old bristlecone pine was discovered in this grove.

Most of the limestone based peaks and ridges above 10,000 ft. in elevation have a mixed forest of bristlecone and limber pine (_Pinus flexilis_) with enclaves of pure bristlecone pine. Elevation, exposure, slope, and soil type and depth are the primary influences for variations in individual trees and groves. Harsher sites have the stereotypic slow-growing, ancient, contorted (28-30 ft. tall), weather-beaten trees with 7 to 10 trees per acre. More protected sites produce relatively tall (48 ft.), straight trees with a density of 74 to 112 trees per acre (Klemmedson and Beasley, 1967). These trees live 300-500 years as opposed to several thousand years at the harsh sites.

It is estimated that tree ring chronologies for bristlecone pine in the South Snake Range could span 7,000 years. Greatly increased growth rates observed in bristlecone and limber pines (LaMarche, et.al., 1984) since the mid-19th century exceed those expected from climatic trends, but are consistent in magnitude with the global trends of increasing carbon dioxide. The Laboratory of Tree-Ring Research, University of Arizona, conducted several studies in the South Snake Range between 1958 and 1984.

Since the Park has a legislative mandate to continue livestock grazing (cattle and sheep), the highest priority for research and management went to developing a Range

Management Plan and it became the first NPS funded project. It is being conducted by Drs. Lee Eddleman and Ray Jaindl of Oregon State University. They are focusing their attention upon the dynamics (climate, fire ecology and livestock grazing) and mapping the vegetation (ground-truthing satellite imagery) for inclusion into the GIS. The wildlife component of range management will be analyzed in the forthcoming NPS funded resource inventory research.

Other botanical information is being derived from independent research. Dr. Richard Johnson of Washington State University, is investigating the distribution and speciation of alpine plants in the Great Basin physiographic region. In the course of his work, he has described and mapped several category II species and others of limited distribution. Dr. Robert Fogel of the University of Michigan is conducting an inventory of hypogeous fungi. Drs. Stan Smith and Kevin Murray of the University of Nevada, Las Vegas are determining the condition and classification of riparian areas in the Park.

The steep elevational gradient of the mountain range has created narrow ecotones between a wide variety of plant communities from high desert scrub to alpine tundra. Given the scenarios of increased temperature and decreased site water balance associated with global climate change, several forest species in the South Snake Range will be forced to move upslope or have restricted distributions. Englemann spruce Englemann spruce, *Picea englemannii,* is at the edge of its natural distribution now, and is projected to decrease over its entire range. (Leverenz and Lev 1987) Ponderosa pine, *Pinus ponderosa*, is isolated beyond its primary distribution today, and is relegated to several small relict stands. Bristlecone and limber pine may suffer a similar fate. However, Douglas fir *Pseudotsuga menziesii,* may recede to an isolated habitat beyond its present range. Ecotonal shifts and treeline fluctuations will be important to monitor.

Jan Gunlock

Vertebrate Biology

As with the botanical research possibilities, the UNR committee thought that the Snake Range offered a unique opportunity to study vertebrate taxonomy, biogeography, speciation, adaptation, ecology and physiological ecology. The location of the Snake Range midway between the Rocky Mountain and Sierra Nevada Ranges holds a particular affinity for biogeography and speciation. Since the Great Basin physiographic region contains about 160 north-south oriented mountain ranges interspersed with arid valleys, the ranges tend to be biological islands. The steep elevational gradient from 5,300 feet to 13,063 feet in the South Snake Range results in a diversified and complex pattern of elevational zonation for both plants and animals. The UNR Committee concluded that the Snake Range contains five of the seven Merriam Life Zones of North America or almost as many patterns of plant/animal/climate elevationally as the entire continent of North America expresses latitudinally.

Discussions in the RBI Workshop focused upon biogeography, speciation, and ungulate populations. Philosophical discussions of biogeography dealt with the absence of such animals as the raccoon, black bear and pika — and the historic record documenting the existence of elk, Rocky Mountain bighorn sheep and wolverine. Although beaver exist in the Park today, it was not resolved as to whether they are indigenous or simply the result of man's introduction. It was agreed that, unlike many mountain ranges in the Great Basin region, wild horses and burros are not located in the South Snake Range. Biogeographic examples of regional distribution were discussed such as the three-toed Woodpecker (*Picoides tridactylus*) at the extreme western border of its range, and Steller's Jay (*Cyanocitta stelleri*) at its eastern border.

Dr. Dean E. Medin studied breeding bird densities and bird community organization along an elevational transect in the Lehman Creek drainage for three years from 1981 to 1983. (These quantitative assessments used spot-mapping methods on 20-hectars plots per habitat type.) In the shadscale habitat, the most common breeding birds were the Horned Lark (*Eremophila alpestris*), Brewer's Sparrow, and Sage Thrasher (*Oreoscoptes montanus*). The Horned Lark accounted for continuous breeding territories with total bird density in the lower 90 percentile. In the upper sagebrush-grass zone, 25 species were territorial with the most abundant species being Brewer's Sparrow (*Spizella breweri*) and Green-tailed Towhee (*Pipilo chlorurus*). Another 16 species were occasional users of the shadscale habitat; half of which were raptors. The bristlecone pine forest in the Wheeler Peak cirque had 82 pairs of breeding birds per 40 hectars with 14 species being territorial. The most abundant species were the Dark-eyed Junco (*Junco hyemalis*), Mountain Chickadee (*Parus gambeli*), Mountain Bluebird (*Sialia currucoides*), and the Townsend's Solitaire (*Myadestes townsendi*). They collectively accounted for 53 percent of the bird population. The alpine study area was on Bald Mountain on a north-facing slope with persistent snowfields, sparse vegetation of mostly low perennial herbs, and over 40 percent of the plot covered by rock. Only two breeding bird species nested in this plot: Water Pipit (*Anthus spinoletta*) and Rock Wren (*Salpinctes absoletus*). Rosy Finches (*Lewcosticte arctoa atrata*) frequented the study plot as foragers on and near the snowfields. Six species were occasional visitors to the alpine zone with another eight species being less frequent visitors.

Table 3 — Density, species richness, and standing crop biomass of breeding bird communities in different vegetation zones, southern Snake Range, NV. (Medin, 1990b)

Vegetation zone1	Number of breeding bird species	Breeding bird density	Standing crop biomass	Source
		Individuals/ha		
Alpine tundra 2	1-2	0.37-0.52	8-10	Medin 1987
Bristlecone pine	14	4.10	95	Medin 1984
Mixed conifer	18-22	7.28-7.70	175-194	Medin,unpublished
Upper sagebrush-grass	22-23	7.07-7.58	158-172	This study
Pinyon-juniper	13-15	3.65-3.90	77-80	Medin,unpublished
Lower sagebrush	5-6	3.35-3.48	53-61	Medin,unpublished
Shadscale	2-3	1.38-1.62	42-49	Medin 1990

(1) Descriptions of the dominant vegetation in each zone are in Cronquist and others (1972).

(2) One year of study; information on all other zones based on 3 years of study.

For small boreal mammals, the Snake Range illustrates the island biogeography principle that larger islands should have more species and larger populations than smaller islands. Of the ten species considered by Dr. Paul Ehrlich (1988), the Snake Range possessed all of them while the adjacent Schell Creek Range had eight species and the smaller Spruce Mountain Range (north of Ely, Nevada) contained only four species. Unlike mammals, bird species appear to fit in the immigration-extinction equilibrium principle of island biogeography, being more dependent upon suitable montane habitat than restricted by arid basins (Ehrlich et al 1988).

Discussions on rare, threatened and endangered species during the RBI Workshop regarded the spotted bat (*Euderma macalatum*) near the Park in Model Cave, the relict populations of Bonneville cutthroat trout (*Oncorhynchus clarki utah*) in some west slope streams, and peregrine falcon (*Falco peregrinus*) as vertebrate candidates for recovery plans. Concern was voiced for the survival of the Rocky Mountain bighorn sheep in the South Snake Range. They were reintroduced in the Snake Range in 1979-80 by the Nevada Department of Wildlife (NDOW). While the North Snake Range population has grown from 30 to 50 or 60 animals, the population in the park has dwindled from 30 to 10 or 15. An obvious difference between the mountain ranges is the presence of 3,100 domestic sheep from mid-June to Mid-October in the South Snake Range. The transmission of communicable diseases from domestic to bighorn sheep is well-documented as a causal factor in the extirpation of bighorn sheep, and it may be the limiting factor in the South Snake Range.

Ungulates received attention at the RBI Workshop because of park neighbors' concerns about a large, increasing mule deer population and the natural re-establishment of elk. Since elk have long been considered transient by local ranchers and hunters, and the historic record relates sightings of individuals rather than herds, the Workshop consensus was for the NPS to take a passive role. Since the winter range was generally considered to be marginal, allowing elk to establish a relatively small resident herd was recommended, but the Park should develop a well-defined strategy through research and planning. By contrast, the NDOW has noted a gradual increase in the mule deer population since the 1960's. The herd is considered large today, and the RBI Workshop recommended the development of a monitoring plan to detect change coupled with research to define the role of deer in range management.

In most instances, the RBI Workshop recommended that research focus upon inventories. According to the Step Down Chart, these will require a literature review, an analysis of distribution and abundance, and a determination of the effects of abiotic resources (soils, climate, etc.)(*Level N-I 5*). After the fisheries inventory is completed by NDOW, a feasibility study is proposed to eradicate alien salmonids from selected streams for the eventual reintroduction of Bonneville cutthroat trout. The research, planning and management action should comply with the requirements under "restore disturbed resources" and "inventory of natural resources..." in the Step Down Chart (*Levels N-I 3-6 and M 4-8*). Three prerequisites exist for future inventory and monitoring research beginning with the RBI funded projects in fiscal year 1990 (NPS funded): on-site GIS computer hardware and software, a computer specialist, and development of an interdisciplinary methodology. These RBI projects will attempt to satisfy several RBI Workshop project statements: An Order 3 Soils Survey, an a Fire Fuels Inventory, Inventory and Assessment of Geological Resources, Cave Inventory and Classification, and Riparian Vegetation Classification, Description and Mapping. However, the present range management research and planning effort was not fully funded, and additional NPS monies have been requested for evaluating the wildlife component of range management. To comply with the Step Down Chart, this research will focus upon ungulate populations, range utilization (competition), and disease. Predation remains as a separate study.

Invertebrate Biology

The UNR committee concluded that relatively few mountain ranges have the degree of complexity in evolutionary trends, speciation and adaptation as the Snake Range. If butterflies and moths are any indication of invertebrate trends, threatened or endangered and extremely restricted species or subspecies should be expected. There is evidence among invertebrates of several semi-isolated gene pools or endemics. Peter Herlan of the Nevada State Museum felt that the butterfly fauna of the Snake Range had strong affinities with the Rocky Mountain center of speciation with little to no Sierra Nevada influence.

The RBI Workshop did not identify invertebrates specifically in the Step Down Chart and only one project statement, "Survey of Aquatic and Terrestrial Invertebrates," dealt with the subject. A more thorough analysis seems appropriate, especially when considering the interest of independent researchers.

Dr. William L. Pratt of University of Nevada Museum of Natural History, Las Vegas, conducted a preliminary study of terrestrial snails, and estimates that 15 to 20 species may exist along the elevation gradient from the valley marshes to the alpine meadows (Pratt, pers. comm.). Of these, 13 to 15 species may occur within the Park, and in biogeographic terms, some terrestrial snails species are restricted to the region and are narrowly endemic. An *Oreohelix species*, as yet unidentified, was discovered in an earlier archeological study of caves in the South Snake Range. Fossil snails provide a tool for reconstructing past habitats.

Mr. George Austin (1989) of the Nevada State Museum, inventoried butterflies and identified 88 species in the Lehman, Baker, and Snake Creek watersheds; some were particularly indicative of island biogeography. Although there are some 600 butterfly species in North America, there is a potential pool of perhaps 110 species in an area of some 400 square miles around the Snake Range (Ehrlich et al 1988). Another investigator working for the Museum, Stephanie McKown, is collecting and identifying macro-moths to expand our baseline information. Dr. Mervin Nielson of Brigham Young University is surveying the Park for species of leaf hoppers. Dr. Peter Starkweather of the University of Nevada, Las Vegas, is sampling the alpine lakes in a preliminary study of zooplankton. In some instances, he is examining the organism's mitochondrial DNA to determine relationships. All of this research is designed as basic inventory, a prerequisite for determining the "distribution and abundance of biotic resources" of the Park as stipulated in the Step Down Chart (*Level I 5-7*).

Paleoecology

Neither the UNR Committee or the RBI Workshop delved into paleoecology, yet recent studies indicate that the variety and extent of paleoenvironmental data offered in the Park and Snake Range are perhaps unmatched within the National Park System. The specific research opportunities involve the analyses of paleohydrology, pollen spectra, tree-ring sequences, woodrat middens, and cave faunal deposits.

The closed hydrological systems characteristic of the Great Basin region exist in and around the Park. Core studies of past pollen spectra from alpine lakes, springs, and valley marshes can, through analogy with modern pollen spectra, be used to reconstruct local and regional vegetation history and, from that information, derive past climate (Bright 1966; Davis 1986; Mehringer 1985; Mehringer 1986; and Wigand 1987). Closely sampled sediment cores can generate a pollen record that can be correlated to local bristlecone and limber pine tree-ring sequences for high-resolution climatic reconstruction. During wet years pollen size increases and production may increase by as much as four to five fold (Mehringer and Wigand, in press). This reconstruction can be extended beyond the range of tree-rings. Fossil woodrat middens provide precise information about the past surrounding vegetation. The numerous, dry limestone alcoves and caverns of the Snake Range shelter fossil middens and provide excellent research opportunities. There have been 57 middens sampled in the North Snake Range to create a paleoecological record that extends 37,000 years back in time. Among other things, the fossil midden record shows that pinyon pine entered the Snake Valley between 6,200 and 6,500 years ago. Today, pinyon pine is a major component of the montane forest, occupying some 20 percent by acreage of the South Snake Range.

Stable isotopic ratio studies can contribute valuable information about climate change within the relatively small area of the Snake Range: hydration rinds of tephra collected from alpine lake cores; glacial and cave ice cores; and cored speleothems. This paleohydrologic record can be compared with the above biotic record as well as the record of human occupation which spans the last 12,000 years.

CULTURAL RESOURCES

Archeological Resources

Archeological resources identified at Great Basin National Park include prehistoric artifact scatters, extensive rock art sites and caves or rockshelters, some with substantial midden deposits. A number of historic period sites have archeological deposits worthy of further investigation. Prehistoric occupation of the park dates from the Paleo Indian period (12000 B.C. to 9000 B.C.) through the Great Basin Desert Archaic (9000 B.C. to A.D. 500), the Parowan Fremont (A.D. 500 to 1300) and the Western Shoshone periods (A.D. 1300 to present). Historic Euro American activities are reported for this area as early as 1859.

The earliest archeological discoveries on lands within Great Basin National Park were caves and rockshelters. These sites often have rock art or midden deposits. Mark Harrington (1934) recommended that William and George Evans be allowed to excavate at the Baker Creek Caves. The Evanses were paid a stipend by the state of Nevada for their work in 1925. Harrington excavated in Upper Baker Creek Cave in the years 1932 to 1934 and his wife Edna wrote a short article on the rock art of these caves (Harrington 1933)(Level C-U 7). In 1937 skeletal remains were unearthed during the construction of the new entrance tunnel at Lehman Caves (Stewart 1938). This led to the 1938 archeological excavations conducted by George M. Wheeler (1938). In 1939 Wheeler explored several cave sites in the park (Wheeler 1939). Over the next 24 years a few archeological site records were prepared for cave and rock art sites in the park but no reports on any of this work are known.

In 1963 Rozaire (1964) conducted excavations in the original entrance rooms of Lehman Caves. He recovered bone, fragments of a bow, chipped stone and historic period artifacts. The latter date to early tours of the cave conducted by Absalom Lehman.

The National Park Service has been involved in the management of rock art site 26WP134, although it is located west of the present park boundaries. The site consists of rock art elements found on large boulders and on smaller, portable rocks. The site was recorded in 1968 and many of the glyph-covered rocks were removed in 1970 (Aikens 1978)(Level C-U 7). This rock art is managed by the U.S. Forest Service and they plan to return the glyphs to their original locations.

Prior to construction projects, eight clearance surveys have been conducted between 1972 and the present. Under the direction of Fowler (1977) the entire 1-square-mile Lehman Caves National Monument was surveyed and two prehistoric artifact scatters were recorded. Test excavation at one of these sites, 26WP740, was conducted by Whittaker and Kamp (1979) prior to the construction of a sewage lagoon. Sites in the park were visited by researchers from the University of Maine (Bonnichsen and Birnie 1984) in their search for late Pleistocene and Early Holocene remains. In his rock art study of the Snake Range, Alvin McLane visited 13 rock art sites in the park and updated the site records for these sites.

A crew from the Western Archeological and Conservation Center in 1989 surveyed developed areas and proposed development areas, assessed 16 of 24 identified historic period properties and visited a number of previously recorded sites (Wells 1989)(Level C-U 7-9). They recorded 45 sites.

The UNR Committee felt that the Snake Range was important archeologically because of the migrations of different peoples through the area, their relationship to past climates, and the extent of their cultures. These researchers had specific interest in the: Puebloid village sites of Snake Valley representing the western-most expansion of this culture; the lithic sites along the fossil Bonneville Lake shoreline indicating possible prehistoric occupation; and the Goshute and Southern Paiute Indians occupying the area at the beginning of the historic period.

In 1988 an archeological overview of Great Basin National Park was prepared by Deal (1988)(Level C-U 7). Deal discusses previous research at the park, outlines the culture history and describes the environment. General management recommendations and suggestions for future research are part of this overview.

The greatest need at this time is to complete the archeological recording of at least 8 known archeological sites and 8 historic period sites. Priorities for long-term management must then be established. In addition to inventory survey, the sites should be assessed for significance and priorities for resource treatment must be established. The potential impact to cultural resources of proposed construction projects must be considered early in the planning stages of a proposed project to allow time for inventory, assessment, planning for avoidance or mitigation of impact, and, if necessary, the production of compliance documents as well as data recovery.

Historical Resources

The earliest extant historical documents for the Wheeler Peak area date from 1827 when Jedediah Smith traveled along the Snake Range and re-entered Utah near Gandy. Mormon explorers reconnoitered the region in the 1850's and established an agricultural settlement south of Baker in 1855. They left after one winter and reported that the area was not suitable for agriculture. As a result of the threat to the Utah Expedition in 1857-58, Mormon scouts explored the area, looking for possible locations to serve as sanctuaries. The next to arrive in Snake Valley were Bill Gregory and Daniel Gonder, whose first attempt to settle the area occurred in 1862.

The first comprehensive study of the Snake Range and adjacent valleys was conducted in 1859 by Captain J.H. Simpson while attempting to locate a wagon route for the U.S. Army from Camp Floyd, near Utah Lake, to Genoa, Nevada. His journal and report, which were published in 1876, included data on topography, climate, wildlife, Indians, botany, geology, and paleontology.

In 1869 Lieutenant George M. Wheeler of the U.S. Corps of Engineers conducted a topographical and geological reconnaissance of the area as part of what would become his extensive U.S. Geographical Surveys West of the One Hundredth Meridian. His studies provided considerable documentary knowledge of the area, and it was his name that became the official designation for Wheeler Peak.

The year 1869 witnessed the beginning of white settlement in Snake and Spring valleys and the establishment of six mining districts in the area of present-day Great Basin National Park. Prominent family names among the early homesteaders and ranchers in Snake Valley included Hockman, Baker, Lehman, Weaver, Gonder, and Eldridge, while those in Spring Valley were Yelland, Kirkeby, Willard, and Robison. The expansion of mining districts in the region was the result of exploration in the wake of the White Pine mining rush in 1865 (Level C-U 9-12).

During the 1870's and 1880's the U.S. Coast and Geodetic Survey established a triangulation station on the summit of Wheeler Peak. The station was used during the

2,500 mile arc of triangulation along the 39th parallel of latitude, the first large land-scale trigonometrical survey in the nation.

The South Snake Range area became part of Nevada National Forest in 1909 under the administration of the U.S. Forest Service. The forest boundaries changed on several occasions; most notable were 1919 and 1957 when the forest became a part of Humboldt National Forest.

Absalom Lehman was a rancher/farmer/miner who settled in the Lehman Creek drainage in 1869 and probably discovered the cave that bears his name during the mid-1880's. He supplied the nearby mining towns with meat, dairy products, vegetables, and fruit and began improving the cave and providing guided tours in 1885 (Level C-U 9-12).

In 1922 a one-square mile area around the caves was established as Lehman Caves National Monument under U.S. Forest Service administration. In 1933, the monument was transferred to the National Park Service. Interest in establishment of an enlarged national park in the Lehman Caves -Wheeler Peak area commenced in the 1920's, and after a renewed campaign that began in 1955, and resurfaced in the early 1980's, Great Basin National Park came into existence on October 27, 1986.

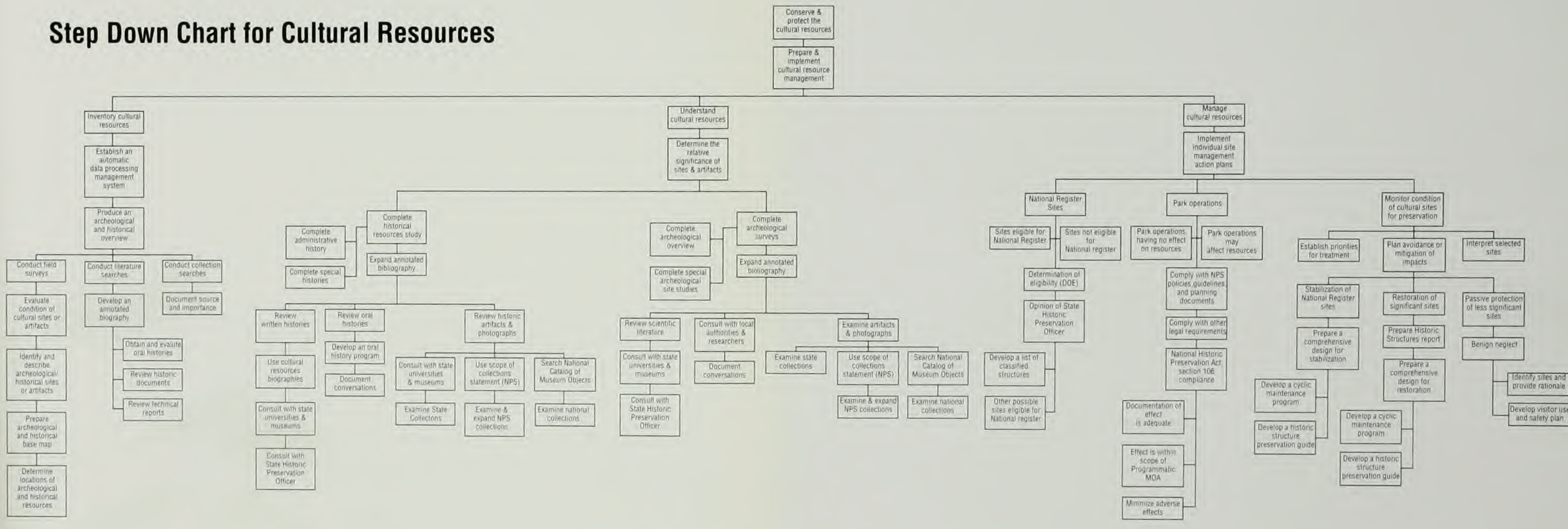
Two documentary historical studies of Lehman Caves National Monument and Great Basin National Park have been prepared, to date. In 1966, Keith Trexler, wrote a history of Lehman Caves entitled, *Lehman Caves...It's Human Story From the Beginning Through 1965*. Park personnel later updated the document through 1975. In 1989 Harlan Unrau produced a Historic Resource Study as part of the General Management Plan for the park (Level C-U 7). The report covered the historical development of the park area, and included a historic base map, draft National Register form for the Osceola Ditch, and an annotated bibliography.

At the present time Darwin Lambert, former Editor of the Ely Daily Times and currently of Luray, Virginia, is researching a complete park history (Level C-U 7). The Lehman Orchard and the Rhodes Cabin were entered on the National Register of Historic Places on February 25, 1975 (Level C-M 6-10).

The UNR Committee concluded that the Snake Range was one of the least known historically in Nevada, and thought that obtaining the information would require considerable research. No specific topics of interest for future investigations were identified, but their discussion focused upon early explorers and homesteaders, timber harvest, and mining. Around the turn of the century, there were sawmills in Big Wash and Lexington Canyon (Warlick or Wallick), Lehman Creek, Strawberry Creek, Snake Creek, and Baker Creek drainages (Tilford and Merchan). From 1868 to 1918 there were some 10 mining districts in the mountain range. An NPS Solid Mineral Operations Monitoring Survey in 1988 provided baseline data for a number of the historic period mine sites (Level C-M 8).

Future history-related documentation needs to include special history studies and the development and implementation of an oral history program. Topics that should be further documented in the special history studies are: ranching/settlement/homesteaders; mining, especially Osceola Ditch (exploration/development/methodology/production); grazing (historical practices and government regulation efforts); and U.S. Forest Service administration of South Snake Range (management policies and operations/development). An oral history program should be developed to conduct interviews with area miners and ranchers, long-time residents, former Forest Service and Park Service officials employed at Lehman Caves, Nevada National Forest, and Humboldt National Forest, and persons who were actively involved in the campaign to have the park established.

Step Down Chart for Cultural Resources



SOCIO-ECONOMIC FACTORS

Providing for public use and enjoyment is accomplished through the parallel activities of visitor use management (visitor protection and interpretation functions) and efforts to better understand the visitors themselves. Understanding visitor use is a goal of social science research at Great Basin National Park. The research program described here focuses on enhancing the management of visitor use by providing relevant visitor information to managers and identifying recreational opportunities within the Park and surrounding region. Research designed to assess the actual management process or its many sub-components is a task for others and is not discussed.

Research did not stop at the Park boundary, but sought to broaden understanding of the social and economic impacts of national park creation on the setting and its region. This regional perspective is necessary for understanding the full implications of visitor use within the Park and the socio-economic influences of national parks, in general. From this research perspective, the Park and its influence do not functionally stop at its geographic boundary. It is more realistic to examine visitor use of the Park and its effects on the region in terms of an interrelated resource system. Past and planned social science research at Great Basin N.P. is designed to provide park managers with a better understanding of the role the park plays within this regional system.

Visitor Use

The ongoing social and economic research is designed to better understand visitor use within the Park and its impacts on the surrounding area. It includes four main areas of investigation: assessing and monitoring visitor impacts, visitor preferences, public interest group relations, and visitor behavior.

Visitor impacts accrue to the Park and to the surrounding region. The 1988 visitor profile indicated that 68 percent were part of a family group. Visitors were primarily from either Utah (30%), California (27%) or Nevada (21%). For 70 percent, this marked their first visit to the Park (established in 1986). The 1989 Easter weekend survey showed that 79 percent of the visitors were part of a family group and were primarily from Utah (66%), Nevada (11%) and California (8%). Sixty percent were visiting for the first time. Visitor impacts to park resources occur to the natural environment and to the experiences of other visitors. The five year average visitation at Lehman Caves National Monument preceding the creation of the Park was 38,000 per year while it has risen to about 75,000 for Great Basin National Park. The impacts from increased visitation are only being evaluated on the visitor experience and regional economic resources. (Level S-U 3)

Visitor impacts to regional resources are largely economic in character (Levels S-U 4-7). Regional economic impacts occur as the result of purchases of food, lodging and other goods and services along travel routes to and from the Park. Park visitors spent an average of $26.00 per party for transportation (gasoline, car rental, etc.); $23.00 per party for retail items (groceries, gifts, clothing); $16.00 per party for restaurants and taverns; and $11.00 per party for lodging (camping and motels). Transportation (29%) and retail (25%) expenditures accounted for the largest percentage of their total expenses. The figures for the Easter weekend were very similar except that transportation costs were up to 35 percent.

Within the region, resident lifestyles can also be affected by Park visitors in ways that are not economically based. Use of the Park by regional residents may be affected by visitation to the Park from those outside the region. The increase of travelers to the Park may also lead to increased demand for local services and facilities, along with higher prices for residents of regional communities. These conditions may detract from the quality of life for some residents while enhancing the lives of other residents.

One visitor impact study has been completed and another is underway in 1990. During 1988 a tourism services inventory was conducted for White Pine County, Nevada. The inventory gathered baseline data with which to document the number, kind and location of tourism services in the county surrounding Great Basin National Park (Level S-I 3). Results will contribute to an understanding of the region surrounding the Park and how the social and economic structures within the region change over time.

During the summer of 1990, a survey of residents of White Pine County will be undertaken to document work and recreation patterns within the region. The study will document traditional uses of natural resources now located within the Park and assess how those uses may have changed since the Park was established.

In order for visitors to the park to receive a satisfying experience their experiences must, to some degree, parallel their preferences and expectations. Knowing what preferences and expectations visitors hold for their visit allows managers to provide more fulfilling opportunities within the guidelines for resource protection and visitor safety.

As part of a general use study conducted in 1988, an in-depth survey was conducted to assess visitor expectations for the Park. Part of this study identified preferences for facilities at various locations within the Park (Levels S-U 3 & 4). Two-thirds of the visitors spent from one to five days in the Park and regarded the Lehman Caves tour as a high point of their total experience. Other popular activities included sightseeing by vehicle (82%), camping (71%), hiking (68%) and observing wildlife (67%). Having an unspoiled Park environment was extremely or very important to 90 percent of the visitors surveyed. Other important conditions to their visit included available drinking water, campgrounds, a safe environment and signs on roads and trails.

The study also gathered data about visitors' evaluation of and expectations for interpretive activities within the Park. Visitors were asked to provide information useful for developing interpretive programs to meet the informational and educational needs of the visitor and park management, as well. For example, of the interpretive services provided in 1988, respondents used the Visitor Center most often: displays (93%), informational brochures (86%), the cave tour (84%), the information desk (75%) and the slide show/movie (65%). Questions relating to potential interpretive services showed that visitors were primarily interested in interpretive trails (68%), interpretive displays at trailheads (62%), self-guided vehicle tours or nature walks (51-64%), and scenic roadside turnouts (55%).

Public interest group support can be a valuable resource to park management. Many public interest groups can provide managers with a motivated, well-organized volunteer force for resource protection, maintenance and other administrative functions. Public interest group members also are an important liaison with the public at large. In this role interest groups can be instrumental in mobilizing public opinion toward park management issues.

Park public interest groups active within the region will be identified as part of the resident survey of White Pine County being conducted in 1990. Identification of decision leaders and members of these groups will allow for enhanced communication with these facets of the visitor public.

Managing visitor behavior, along with resource management, are two central tasks of park managers. In order to make informed decisions about the allocation of human and fiscal resources, managers need to know the nature, time and location of visitor activities within the Park. Tracking visitor behavior through monitoring changes in use levels and activity types over time allows for pro-active management of park resources, thereby improving visitor satisfaction and resource protection (Levels S-M 3-5).

Several research projects conducted or planned assess visitor behavior within the Park. The 1988 visitor use survey was a detailed study of visitor behavior throughout the Park. In 1989, an Easter weekend visitor survey was conducted to describe visitor characteristics and visitor behavior during this high visitation period. Finally, during 1990, a one-week visitor "pulse" survey of visitors was conducted in order to monitor changes in the visitor population, including activities and preferences, that may have occurred since the 1988 visitor study. It is hoped that these brief visitor "pulses" would continue periodically, such as every five to ten years, to document changes in the visitor population at Great Basin National Park.

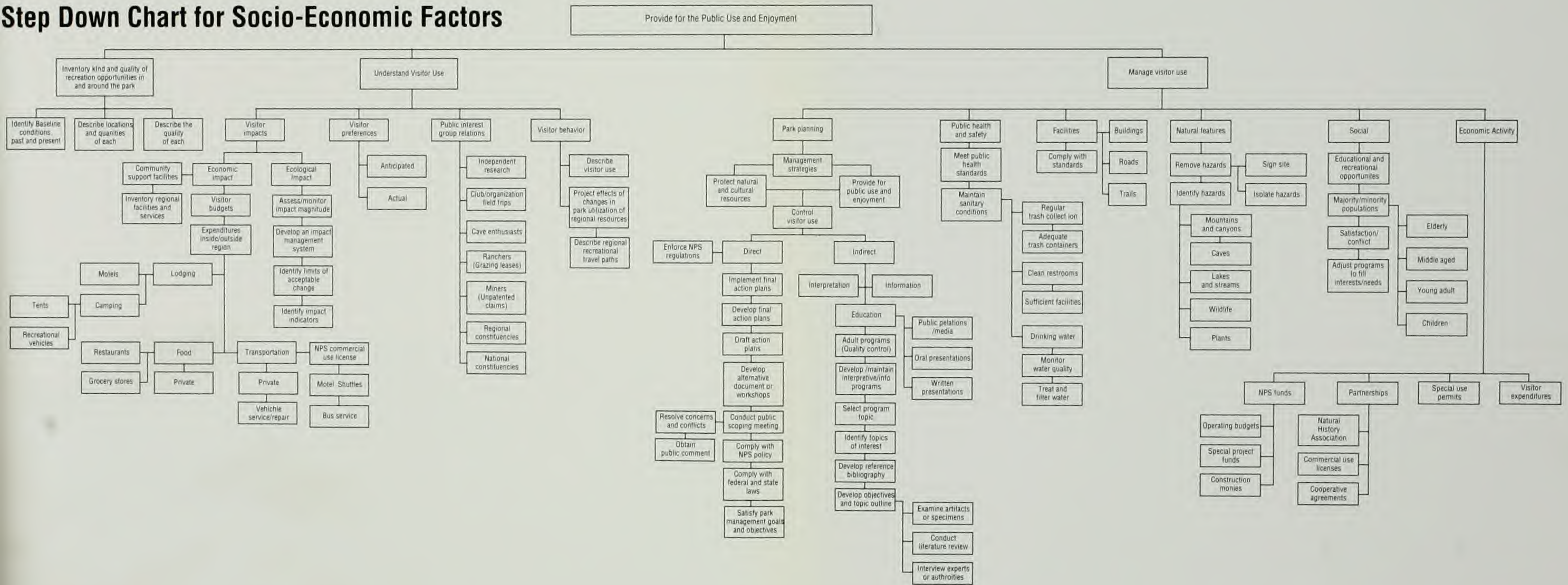
Inventory of Recreation Opportunities

Providing a range of opportunities provides a variety of experiences for park visitors. Not all visitors come to a park seeking the same activities, settings or experiences. The first step to providing a variety of quality experiences is to inventory existing resources, both natural and management-created, to identify the experience opportunities available - both within the Park and in the surrounding region. The "supply" of experience opportunities can then be compared with visitor preferences and expectations to see how visitor needs are being met.

A management system such as the Recreation Opportunity Spectrum (ROS) (Clark et al 1979) may be a useful tool for inventorying recreation opportunities within the Park and the region. Use of this system involves systematically mapping the recreation opportunities available by combining mixes of activities, settings and recreation experiences into six classes along a spectrum: primitive, semi-primitive non-motorized, semi-primitive motorized, roaded natural, rural and urban. Criteria used to classify lands take into account the physical setting (such as size, screening and isolation), the management influence present (facilities, regulations, etc.), and the social setting (numbers and types of other visitors present). Each ROS class, then, provides a set of experience opportunities that are a function of the kinds of settings and activities available (Levels S-I 3 & 4).

A general inventory of recreation opportunities within the Park and surrounding region was used by the General Management Plan (GMP) Team in formulating the GMP Alternatives document.

Step Down Chart for Socio-Economic Factors



SUMMARY AND CONCLUSION

The RBI Workshop easily consumed the three days which we scheduled and met at least four of the seven objectives in the process. It also promoted this publication as a logical extension of the Step Down Chart in an effort to explain how the project statements and other research priorities identified in the Research Perspective relate to this flow diagram. Our initial emphasis is on conducting inventories, but interested researchers or resource managers should be able to evaluate their draft proposals against our identified needs to determine the required elements and degree of compatibility. We wish to encourage independent research wherever possible within this framework.

A cadre of five facilitators led certain sessions, monitored others, and met at the end of each day to assess progress and adjust the next day's schedule. This flexibility was necessary because the RBI Workshop process is a fluid one of brainstorming with an academic group purposely representing an array of disciplines. Most of the first day was devoted to orienting the participants to Great Basin National Park: NPS policy, the Park's legislative mandate, natural resource management issues, the GMP/EIS planning effort, acquired baseline information, participant feedback, and an introduction to the Step Down Chart. The day essentially went as scheduled; however, the second day was entirely devoted to the Step Down Chart as opposed to our original thoughts of spending half the day developing the chart and the remainder writing project statements. The third day began with refinements to the chart, then participants divided into work groups to write project statements. These consisted of identifying past and present conditions, alternative actions and probable impacts, recommended action (research, monitoring, and resource management), and funding requirements. Twenty-one project statements were developed.

Our first objective was to create a bibliography as specific to Great Basin National Park as possible. Since we had requested a selected bibliography from each participant in advance of the RBI Workshop, this objective was realized almost immediately. As a result, our RBI bibliography consists of some 600 references, is computerized for easy access, and will be published separately. It will prove to be invaluable in determining baseline information for its first major application, writing the Environmental Impact Statement for the General Management Plan. The RBI Workshop also provided an opportunity for the Park staff to interact with professors from several universities with expertise in the biota of the Great Basin physiographic region. Future communications with these universities should be easier with these personal contacts.

The natural resource issues were given to the participants as background information prior to the RBI Workshop and reviewed with a slide presentation before the GMP/GIS session. The second RBI objective was easily satisfied. As a result, the response to the GMP team and the GIS representative presentations developed into a productive dialogue while serving to further orient the participants to the Park through an assortment of maps and graphics.

Determining the resource baseline information research and resource management needs evolved in a general sense through the process of developing the Step Down Chart. Aside from fulfilling its main purpose, the chart graphically differentiates between the research and resource management functions for park operations. It also serves as a checklist or flow diagram for prioritizing project statements and evaluating research proposals. In essence, it outlines the rationale. However, because of the time required to construct the Step Down Chart, the RBI Workshop participants did not have time to assess available information, deficiencies or to establish priorities.

To make the step down process more time efficient, it is recommended that the first four or five levels be introduced to RBI Workshop participants as a starting point—at least for most National Park Service areas. Other land management agencies should modify the first and second levels to reflect their policies and legislative mandates; however, only a few changes may be necessary to level three to five. The time saved during this session could be applied to creating a more detailed chart or dividing project statements into smaller research, monitoring, and management action components. For our purposes, the Step Down Chart is envisioned as representing a dynamic process, requiring updates and refinements every three to five years. As research and resource management efforts achieve their objectives, more elements at the lower levels of the chart can be graphically shaded to depict the degree of completion. As the subject matter becomes better known, new questions with corresponding project statements and priorities will evolve.

The RBI Workshop and subsequent analysis of research proposals and resource management actions has provided us with an entirely new perspective. The RBI Workshop dealt with natural resource concerns, but the additional Step Down Charts and Research Perspectives for cultural resources and sociology by other contributors enabled us to analytically comply with the legislative mandate for Great Basin National Park. Newly acquired databases can be integrated using the GIS computer with such baseline themes as geology, topography, soils survey, hydrology, and vegetation for more detailed analyses. Independent studies within the RBI framework are encouraged and will be supported wherever possible by the Park.

Visitor Center, 1932 Photo courtesy of Great Basin National Park.

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As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

May, 1992

Designed and published by the University of Nevada, Las Vegas • Publications/Reprographics Department.