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Taming the wild pecan at Lyndon B. Johnson National Historical Park

By Marvin Harris

Preface

When President Johnson donated the LBJ Ranch to the people of the United States, one of the few requests he made was that the ranch "…remain a working ranch and not become a sterile relic of the past." To that end, Lyndon B. Johnson National Historical Park, Texas, is attempting to preserve a cultural landscape that includes the ranching and farming activities that LBJ engaged in when he lived here. The pecan orchard, along with other crops and the cattle herd, is managed for sustainable production. The goals are to produce a crop using the best management practices available and to adhere to NPS policies and regulations. Among the policies that we adhere to are those concerning integrated pest management (IPM). The Pecan IPM Plan will meet this responsibility, by reducing the use of pesticides to an absolute minimum, while still fulfilling the cultural and natural resource mandates of the park.

Introduction

National parks provide insights into many facets of the United States of America from the wild beauty of preserved wilderness to carefully managed agroecosystems that reflect our reliance on nature for sustenance and livelihood. The Lyndon B. Johnson National Historical Park contains much of this spectrum within its boundaries, and one plant species in particular provides a link from the frontier of the past to today's society. This plant is the pecan, *Carya illinoensis* (Wang) K. Koch, which is recognized by the Texas Legislature as the state tree of Texas. Cabeza de Vaca's 16th century journal provided the first written record of the pecan. While a captive of American Indians for six years, he noted returning every other year to camp on the river (probably the Guadalupe) to dine for several months almost entirely on pecans. Early traders bartered with wild nuts. Settlers thinned out other trees while leaving the still abundant 100+ foot-high wild pecans to provide nuts and some shade for the cattle that could now graze on the grass that the partially cleared land would support. The wild pecans were the sole source of these delectable nuts until vegetative propagation began late in the 19th century. The pecan is native along the rivers in Texas, and the native range extends eastward to the Mississippi River Valley. George Washington carried pecans as a snack and Thomas Jefferson had trees imported and planted at Monticello, anticipating the massive plantings in Georgia many decades later.

Until the early 1970s, more than 50% of Texas pecan production came from naturally occurring trees. Today, about 35% of the average annual crop of about 65 million pounds in Texas comes from the wild trees. A microcosm of pecan domestication–from wild trees growing in closed canopies adjacent to rivers and streams, to thinned river bottoms suitable for cattle and pecan operations, to a vegetatively propagated pecan orchard (figure 1)–is represented at the LBJ National Historical Park. At the park, an integrated pest management plan has been developed to allow the orchard to be agriculturally productive. The approach to IPM combines an understanding of how natural processes would proceed if left alone, with careful monitoring

Figure 1. Located in the Lyndon B. Johnson birthplace yard, this pecan orchard is managed for sustainable production using integrated pest management techniques. Other pecans on the national historical park are wild and are managed differently.

See "Pecan" on page 20

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Contributors—Elizabeth Rockwell (Information Crossfile)

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IN THE NEXT ISSUE...

Originally planned for this issue, our emphasis on the social sciences in parks will appear next time in *Park Science*. Guest editor Jared Ficker of the NPS Social Science Program has pulled together a broad array of articles that explore the application of economics, political science, sociology, and other social science disciplines in park management. Publication will be in the early winter with a routine edition of *Park Science* following in summer.

Interpretation joins the mix

I am excited to welcome Judy Visty, Fall River District Interpreter at Rocky Mountain National Park, to the Park Science Editorial Board. Judy occupies a new board position that reflects our deliberate effort to be more inclusive of interpretation in the articles contained in this publication. The change will be subtle, but with Judy's help, I will look for opportunities to incorporate the implications of research on interpretive operations in parks and to relate the role of interpretation in sharing the results of research and its application in resource management. Similarly, I welcome Jared Ficker of the NPS Social Science Program as a new board member, serving the interests of the social sciences. His expertise will help integrate this important and growing field into the mix of articles that routinely appears in these pages. Judy's and Jared's appointments are the result of a call for nominees over a year ago and are sure to serve the publication well. Thanks to all who expressed an interest in serving *Park Science* in these positions.

–Jeff Selleck, Editor

NEWS & VIEWS

Corrections

Omission

Last issue, the article on elephant seals at Point Reyes (volume **19(1)**:30-31) failed to acknowledge the financial support for the project from Canon U.S.A., Inc. Since 1995, Canon has provided over $3,500,000 in cash and equipment to 49 parks through Expedition Into the Parks, a grants program administered by the National Park Foundation. We apologize for the omission.

URL in error

Also last issue, the Information Crossfile piece entitled "Popularity of parks affects policy making" cited a faulty URL for the full-length text on the World Wide Web. The URL should have read www.du.edu/law/lawreview/home.html.

Tortoise what?

Lead author Jeff Lovich ("Studies of reproductive output of the desert tortoise…," *Park Science* **19(1)**:22-24) pointed out a humorous error in the caption for figure 3 that ran with the article. A publication layout problem obscured the final word of the last sentence such that it read, "Nests are often constructed in the mouth of a tortoise." The missing word was "burrow."

Any inconvenience this may have caused for the tortoise (or the authors) is regretted. –Editor

Guest editors, ideas wanted

Park Science occasionally publishes thematic issues that explore topics of special interest to resource managers. The bulk of such issues is devoted to the in-depth treatment of the topic. The departments of the publication (Highlights, Information Crossfile, and the others) are unaffected and continue to report their resource management news in the usual way. Examples of past themes are "Global Change" (volume 10(4)) and "Pollution in Parks" (volume 6(4)). Our next issue (volume 20(1)), in the works for more than a year, will be titled "Social Science–Useable Knowledge for NPS Managers."

Thematic issues are commonly put together by a guest editor (or editorial team) who sees a need and has the interest, ability, and specialized subject-area knowledge to solicit, gather, review, edit, and prepare the bulk of the materials for the issue. The editor serves as a technical consultant to the guest editor during development of the concept and materials for the thematic issue, and is responsible for the layout and design of the issue, its printing, and circulation. The Park Science Editorial Board reviews the materials for these issues and may also aid in their development.

Planning for a thematic issue begins with a proposal submitted usually one to two years before release of the publication. A proposal states the theme, its timeliness and relevance to the publication audience, and the article treatments envisioned to systematically cover the topic. It also describes a process and approximate time line for announcing the issue, inviting contributions, and reviewing and preparing the materials for publication. Finally, it spells out the qualifications of the guest editor. The Park Science Editorial Board considers proposals based on the currency of the topic, applicability of the material, budget, and publishing schedule. If selected, the editor and guest editor outline their respective roles and responsibilities and begin work on the project.

Topics suggested recently for thematic issues have included hazardous materials, damage assessment procedures, GIS, ecosystem management, and the contributions of various NPS operations to the Environmental Quality Initiative. If you would like to serve as guest editor to bring one of these ideas to fruition, or if you have a proposal for a thematic issue and a guest editor who could pull the materials together, please contact *Park Science* editor Jeff Selleck (jeff_selleck@nps.gov). Proposals for thematic issues and nominations of guest editors are accepted at any time.

Science scholarship program announced for 2000

The Canon National Parks Science Scholars Program will award scholarships to eight doctoral students in 2000. Each student selected will receive $25,000 per year for up to three years to conduct dissertation research in the national parks. In addition, four honorable mentions will be awarded a one-time scholarship of $2,000.

The competition will focus on four research topics within the biological, physical, social, and cultural sciences. Selected by the National Park Service, the research topics are of critical importance to the management of the national park system. Students applying for 2000 scholarships must submit dissertation proposals that address these topics.

For an application and guidelines, contact Dr. Gary Machlis, Program Coordinator, Canon National Parks Science Scholars Program, Natural Resource Stewardship and Science, National Park Service, 1849 C Street NW (MIB 3127), Washington, D.C. 20240; gmachlis@ uidaho.edu or visit www.nps.gov/socialscience/waso/acts.htm. Applications are due 1 June 2000. Winners will be announced shortly after 7 August 2000.

Highest natural resource honors bestowed

The National Park Service recently presented five individuals with its 1998 Director's Awards for Natural Resource Stewardship. The honors recognize outstanding achievements in the protection of ecosystem health in parks. The awards were given during September at the Society of Ecological Restoration's annual meeting, held at the Presidio in San Francisco. This year's winners have fought to prevent exotic plants from destroying native vegetation, developed programs to inventory and monitor park plants and animals, and applied science to help managers make sound decisions.

Kathy M. Davis, Chief of Resource Management with the Southern Arizona Office (Phoenix) is the recipient of the Director's Award for Natural Resource Management. She is recognized for her leadership in the development and implementation of the NPS Resources Careers Initiative. Under Kathy's leadership, the Resources Careers task force conceived, developed, and completed professional, career-ladder position descriptions and classification evaluation statements in natural and cultural resource series and in interdisciplinary series. Her efforts affect every resource manager in the National Park Service by creating a framework for professionalization and success. Additionally, Kathy serves as an effective resource manager for 10 small parks in southern Arizona.

William Halvorson is the Cooperative Park Studies Unit Leader at the University of Arizona–USGS Biological Resources Division. Halvorson is a champion of research applicabil-

Continued on page 4

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ity in park management. His continual, professional support of park staffs and commitment to quality research and resource management in national park areas in southern Arizona has enabled these units to overcome significant challenges. One of his trademarks is communication of research results through such means as a forum he helped found for the discussion and evaluation of natural and cultural resource programs. Additionally, he published Bajada (a research newsletter) for several years and coauthored an important chapter entitled "A lesson learned from a century of applying research to management of national parks" for the 1996 book, *Science in Ecosystem Management in the National Parks*.

Karen Wade is the winner of the Director's Award for Superintendent of the Year for Natural Resource Stewardship. As Superintendent of Great Smoky Mountains National Park, North Carolina and Tennessee, Karen encouraged her staff to initiate the All Taxa Biodiversity Inventory, an ambitious effort to identify all species living within the park. Under her direction, the park developed a strategy to complete the inventory without significant federal funding. Additionally, Karen is widely regarded as a creative thinker and believes strongly that partnerships among a broad cross-section of constituents are key to solving problems related to park issues. She has recently become Intermountain Regional Director of the National Park Service.

Richard R. Potts II is the Natural Resource Program Manager at Kalaupapa National Historical Park, Hawaii, and recipient of the Trish Patterson-Student Conservation Association Award for Natural Resource Management in a Small Park. In just over three years, Rick has transformed natural resource management at the park from virtual nonexistence into an energetic program that addresses a wide range of issues from an ecosystem perspective. He has identified threats within designated, high priority "special ecological areas" within the park, and obtained funding to equip a vegetation management specialist. Under Rick's leadership, several thousand acres of native Hawaiian ecosystems are being protected from alien ungulates by fencing, administrative hunting by local hunters, and aerial shooting. Also, he has also instituted monitoring programs for key native Hawaiian species, developed population estimates of axis deer and pigs, and helped protect marine and freshwater resources in Kalaupapa. As a result of the award, the Student Conservation Association will underwrite a seasonal SCA Resource Assistant position for the park.

Joseph Dunstan is the Sustainability Coordinator for the Pacific West Region and recipient of the Director's Award for Excellence in Natural Resource Stewardship through Maintenance. Joe is a leader in promoting sustainable practices and opportunity planning in parks. He has been able to increase the role of sustainability in the parks by conducting team evaluations of such park operations as maintenance, concessions and visitor services, handling of waste, and energy uses. The team identifies resources flowing into a park, describes how the activities of staff and visitors alter those resources, and explores ways parks can incorporate additional sustainable practices into daily routines.

Park Science congratulates these winners and encourages readers to be thinking of nominees for the 1999 awards. Nominations will be solicited in the near future on the NPS Natural Resources Bulletin Board on cc:Mail.

Former chief scientists on the move

Over the past two years, three former regional chief scientists with the National Park Service have moved on to other career positions in the federal government and one has retired.

Dr. William Anderson retired from the National Park Service in March 1998. Bill began his NPS career in 1973 as a plant pathologist with the NPS Ecological Services Laboratory in Bay St. Louis, Mississippi. In 1976, he began a five-year stint with the North Atlantic Region as a plant scientist. In 1981, he became the Chief Scientist of the National Capital Region and retired in the position of regional Natural Resource Officer. While with the region, Bill helped establish the Center for Urban Ecology, providing quality laboratory and office space for his staff. He also helped bring about interregional support within the National Park Service for the Chesapeake Bay Initiative.

Dr. Suzette Kimball left the National Park Service in October 1998 to became the Eastern Regional Biologist with the USGS Biological Resources Division (BRD) in Kearneysville, West Virginia. Suzette joined the Park Service in 1991 as the research coordinator for the barrier island component of the Global Climate Change Program. She also served as Southeast Regional Chief Scientist before assuming the position of Associate Regional Director. During her NPS career, she was a member of the NPS Science Advisory Council, Natural Resources Advisory Council, and the ad-hoc geologic resources advisory group. In her new post, Suzette oversees BRD programs, facilities, and services, including seven scientific research centers, for an area that stretches from Canada to the Caribbean and west to the Mississippi River.

During fall 1999, Dr. Dan Huff accepted a detail with Region 6 of the U.S. Fish and Wildlife Service (FWS) to serve as team leader for the development of the Jackson (Wyoming) bison and elk management plan and environmental impact statement. Dan's position is funded jointly by the NPS and FWS under a cooperative agreement. As former Rocky Mountain Regional Chief Scientist and Intermountain Assistant Regional Director for Natural Resources and Science, Dan was a leader in addressing controversial and complex wildlife management issues, serving for several years as the chair of the Greater Yellowstone Interagency Brucellosis Committee. His new position is sure to be similarly important and challenging.

As the article on page 14 explains, Dr. Ron Hiebert has been selected as the first Research Coordinator of the Colorado Plateau CESU in Flagstaff. He remains with the National Park Service in this role. Ron served as the Regional Chief Scientist in the Midwest Region beginning in 1988, becoming its Assistant Regional Director for Natural Resources in 1995. Throughout his career, Ron has been interested in the preservation and restoration of ecosystems and the management of exotic plant species. Additionally, he has been involved with numerous NPS initiatives and work groups and has served as chair of the Park Science Editorial Board since 1994.

All four former regional chief scientists distinguished themselves in their positions of leadership and will be missed. *Park Science* thanks them for their contributions to the resource preservation mission of the National Park Service and for their support of this publication. We wish them success in their new endeavors. PS

Natural history on a little-known island: Cracking Navassa's oyster

ARTICLE AND PHOTOGRAPHS BY JIL M. SWEARINGEN

As an entomologist for the National Park Service, I recently participated in an expedition to survey the natural resources of Navassa Island (figure 1), a small U.S. territory in the Caribbean Sea (figure 2). Located about 35 miles west of Haiti and 100 miles south of Guantanamo, Cuba, Navassa had been under the administration of the U.S. Coast Guard, which operated a beacon there since the early 1900s (arrow, figure 1). In 1996, the Department of the Interior began to administer this 1.9-square-mile spot of land, and in 1998 requested a natural resources inventory in order to determine the island's future status. This was an exciting opportunity to participate in a historic, scientific expedition to document the natural history of a remote, Caribbean island, and a chance to make discoveries that would prove significant in the disposition of the island.

National parks, wildlife refuges, and other protected public lands are set aside, by and large, to preserve unique, uncommon, beautiful, and otherwise exceptional examples of natural landscapes, scenery, historic and cultural resources, geologic and hydrologic features, and biological resources, including large animals or "showy megafauna." While protection of a selected keystone species is sometimes the main purpose for land preservation, the decision is rarely based on good knowledge of the plants, insects, and other less conspicuous occupants of a site. These elements of biodiversity far outnumber vertebrate species and provide essential food and habitat for their mammoth cousins. Large, natural areas such as national parks, nature preserves, and wildlife refuges, are likely to contain significant biological diversity, requiring many years of scientific inquiry to reveal. Navassa Island was certainly an exception to this rule; it was proposed for designation as a U.S.-managed national wildlife refuge in June 1999, based primarily upon the results of our brief, but intensive natural resources survey.

Figure 1 (above). First sight of Navassa Island reveals the beacon (arrow), location of the "dry" team's camp.

Figure 2 (map). Shaped like an oyster, Navassa is located approximately 100 miles south of Cuba and 35 miles west of Haiti.

Survey teams assembled

The Center for Marine Conservation in Washington, D.C., organized the expedition, which consisted of terrestrial (figure 3) and marine resources teams (table 1, page 6). The goal was to conduct as complete as possible inventories of the plants, invertebrates, herpetiles, birds, mammals, fish, corals, and other organisms during a 12-day visit. A geologist was included to sample rocks, soils, and other materials, for the purpose of determining the age and composition of the island and to attempt to unravel the island's geologic history. My role as part of the terrestrial team was to assist with the entomological surveys and to help photo-document the journey and survey activities.

Historical exploration of Navassa

Although our surveys of Navassa Island would be the most comprehensive, they were not the first. The island was discovered in 1504, when Christopher Columbus dispatched members of his crew from Jamaica to Hispaniola to get some badly needed supplies. They encountered Navassa en route and inspected it briefly, becoming the first known to set foot on it. Because the crew reported an apparent lack of water, Columbus had no interest in revisiting the island. Knowledge of the island's natural resources, particularly the flora, began accumulating in the late 1700s. Around 1785, Swedish botanist Olaf Swartz, sailing for Jamaica, passed by Navassa and recorded two cliff-dwelling plant species, which he presumably could see from his ship. The island became U.S. property in 1857 when Peter Duncan, a U.S. citizen, claimed Navassa under the provisions of the newly passed (1856) Guano Act, which allowed any person to lay claim to uninhabited islands that contained large amounts of guano fertilizer. Mr. Duncan set up a mining operation and mined the phosphate guano from 1865-98, with the help of recently freed slaves from Baltimore, Maryland. In October 1928, E. L. Ekman, a second Swedish botanist, spent two weeks on Navassa and reported 102 plant species, 44 of which he believed to be native. He published the results of his survey in the journal "Arkiv for Botanik" in 1929. Fifteen

Figure 3. The terrestrial survey crew consisted of (clockwise from top row, right, ending in center) Robert Powell, Bill Buck, Tom Zanoni, Jil Swearingen, Warren Steiner, Robert Halley, James Oland, and Michael Smith.

"Navassa" continued on page 6

"Navassa" continued from page 5

months later, H. A. Rehder, from the Arnold Arboretum of Harvard University, collected about two dozen plants. He was followed by Dr. George Proctor, a botanist with the Institute of Jamaica, who visited the island for four days in 1956 and documented 38 species of plants.

Before our expedition in 1998, only one invertebrate (a spider) was known for the island and no published records of any insects existed, although two beetle specimens (different species) were located in the Museum of Comparative Zoology, Harvard University. Beyond these, any invertebrates we collected would be new records for the island.

Figure 4. A Coast Guard helicopter, on board the cutter, ferried the survey participants to the island.

Getting there

Against this historical backdrop the terrestrial, or "dry team," met for the first time in Ft. Lauderdale, Florida, on July 21 1998, and began final preparations for the intensive 12-day survey of the natural resources of Navassa Island. We departed early the next morning by charter plane (Fandango Air) for Guantanamo Bay, Cuba, where we spent the night on base and had one morning to purchase all of our food and other perishables for the expedition. In Guantanamo Bay, we were loaded onto a 270-foot Coast Guard cutter (figure 4) for a 12-hour, overnight journey to the island. We were extremely well looked after while under the care of the Coast Guard, whose outstanding logistical support made the terrestrial survey possible. Getting onto the beachless, cliff-rimmed island is treacherous and requires a helicopter for most purposes. A rusted, part-rope, part-steel ladder hangs from a cement slab at Lulu Bay and is used by Haitian fisherman who frequent the island. However, from the cutter anchored offshore, we were ferried to the island by helicopter, along with our supplies and six, 50-gallon barrels of water, requiring nine sorties.

Once on the island, we were impressed and surprised by the vast expanse of forest (figure 5) and highly eroded and pitted limestone rock base. Several grassy savanna-like clearings in the vicinity of the lighthouse were welcome openings. We set up camp at the base of the dismantled lighthouse and in an adjacent roofless building, the base of which, we discovered, held two large cisterns of water. We deemed this water clean enough to use for washing, which greatly reduced the demands placed on our limited drinking water supply. During the following week and a half, we explored the island using limited remnant paths from the mining operations, and otherwise made our way slowly through the dense vegetation with the help of global positioning system units, to prevent our getting lost and also to obtain digital location points.

The surveys

The surveys revealed that Navassa's terrestrial and marine environments have significant biological and cultural values in need of protection. The surface terrain and geology reveal an ancient and isolated island, estimated to be between 2 and 5 million years old, and the island's biota includes a rich diversity of plants and animals, including some that occur nowhere else. The human history of the island is equally interesting and deserves separate attention.

Plants

About 120 plants are known to occur on the largely forested island, dominated by four species of tropical-subtropical trees: *Sideroxylon foetidissima*, *Ficus populnea var. brevifolia*, *Coccoloba diversifolia*, and the highly toxic poisonwood, *Metopium brownei*, that plagued the group with blistering poison ivy-like skin rashes. Two endemic palms occur on the island, one found commonly, and the other barely hanging on as a single live specimen. A number of exotic plants occur on Navassa, including the popular ornamental Madagascar periwinkle *(Catharanthus roseus)*, almost certainly introduced by people visiting or residing on the island during the past hundred or more years.

Invertebrates

In attempting to collect as many different species of insects and other invertebrates as possible during our visit, we employed a wide array of collecting techniques and placed traps in a variety of habitat types and zones. Trap methods included pitfall cup traps (figure 6) and Malaise traps (vertical flight intercept nets) fitted with yellow pans of soapy water set on the ground to catch insects that fall

Table 1. Navassa expedition participants

Terrestrial Resources Team		
Expedition Coordinator	Michael Smith	Center for Marine Conservation
Botanists	Bill Buck & Tom Zanoni	New York Botanical Garden
Entomologist	Warren Steiner	Smithsonian Institution (Dept. Entomology)
Entomologist	Jil Swearingen	U.S. National Park Service
Geologist	Robert Halley	U.S. Geological Survey
Herpetologist	Bob Powell	Avila College (Kansas City, MO)
Ornithologist	James Oland	U.S. Fish and Wildlife Service
Marine Resources Team*		
Marine Mammalogist	Nina Young	Center for Marine Conservation
Phycologist	Barrett Brooks	Smithsonian Institution (Dept. Botany)
Submersible Technician	Ian Griffith	Deep Ocean Exploration & Research (CA)
Phycologist	Diane Littler	Smithsonian Institution (Dept. Botany)
Phycologist	Mark Littler	Smithsonian Institution (Dept. Botany)
Ichthyologist	Llena San	CEBSE & National Mus. of Natural History (Santo Domingo, Dominican Rep.)

*The marine surveys were conducted from the ship Mago del Mar, operated by Captain Rafael Castellanos and four crew, and owned by the Dominican Ministry of Fisheries.

Figure 5. The mostly forested landscape of Navassa Island conceals its rugged terrain of pitted limestone, which required care to safely negotiate during the expedition.

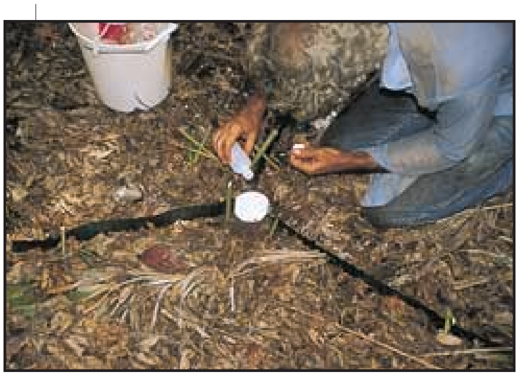

Figure 6. The entomologists used pitfall traps, shown here, and other survey techniques to collect insects and other invertebrates.

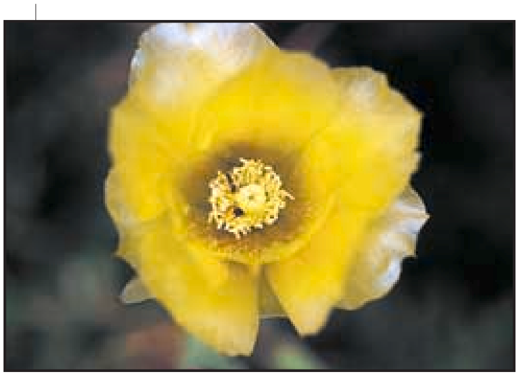

Figure 7. Preliminary results from the terrestrial survey indicate over 500 new insect species records for the island, including an unidentified bee species that was found pollinating a prickly pear cactus (Opuntia nashii).

when they hit the nearly invisible screening. Night-flying insects were attracted using black (ultraviolet) lights against white sheets that were hung at different locations. Various manual methods were used to sample leaf litter, soil, rotten wood, fungi, foliage, air, and water.

A preliminary examination of our collections reveals 650 species of invertebrates, including over 500 new insect species records for Navassa (figure 7), 30% of which may be endemic. Over 100 non-insect arthropods, mostly spiders, make up the rest. Many specialists will be needed to work on this diverse material to get it to final species-level identifications.

Vertebrates

Vertebrate surveys confirmed the existence and abundance of four endemic herpetiles, two lizard species *(Celestus badius* and *Anolis longiceps)* and two gecko species *(Aristelliger cochranae* and *Sphaerodactylus becki)*, all previously reported for the island. Four other known species, including a large endemic iguana that may have been eaten to extinction, and a boa, could not be relocated. Several dozen species of tropical birds inhabit the island, and are dominated by the highly vocal white-crowned pigeon, red-footed booby, and brown booby. A number of cliff-nesting birds including the bridled tern, added to the diversity. No endemic mammals are known to occur on Navassa, and the group is now represented exclusively by introduced species such as the black rat, goat, dog, and possibly cat.

Reflections

This expedition was valuable to me as a scientist and NPS employee, and on a personal level. It was the first "rapid bioassessment" project I had participated in and, while exciting for me, came with some sources of anxiety. First, I was the only female on the terrestrial team and would be living very closely with seven men I had not previously known (except for my husband, the other entomologist on the team) on an isolated, exposed speck of land in the middle of the Caribbean Sea. Secondly, the terrain was extremely difficult to negotiate and the climate was uncomfortably hot and humid. Each of us was keenly aware that a single, serious injury could jeopardize the entire effort and require emergency rescue by helicopter, which was not readily available until the completion of our survey. And, I was selected to join the expedition with only five days' advance notice. Due to the complicated logistics, careful preparation and planning were required before and throughout the course of the trip. Fortunately, the eight of us got along swimmingly. We worked very hard, shared camp duties equitably, learned a lot from each other, and had a lot of fun despite the heat, sweat, and unrelenting poisonwood rashes.

The experience also got me thinking about the general lack of information about invertebrates in most of our national parks and other preserves and the great need for surveys to illuminate this information. Rapid bioassessment-type surveys, such as the one conducted on Navassa, attempt to collect comprehensive information on the biodiversity of an area in a short period of time. Surveys conducted under the NPS Inventory and Monitoring (I&M) Program attempt to identify 90% of the vertebrates and vascular plants in a given park over a longer period of time. Invertebrates, non-vascular plants, fungi, and other critical elements of diversity are not currently included in these surveys. In addition to species lists, the I&M inventories also compile information about the distribution of species in a park (at least for threatened and endangered species or other species of concern), their relative abundance, and their association with habitats. Both approaches to species inventorying, while limited, provide information that helps us better understand the ecological value of our natural resources and can direct us in our land protection efforts. Ideally, biological surveys should be as inclusive as possible and be continued over an extended period of time to document short-lived or highly seasonal species. PS

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Editor's Note: Visitation to Navassa Island requires permission from the U.S. Department of the Interior, Fish and Wildlife Service.

PACIFIC-GREAT BASIN

Prescribed fire effects investigated

Redwood National and State Parks (California) have formed a partnership with the research branch of the USDA Forest Service in order to study the effects of prescribed fire on ecosystem function of coastal prairies. The study site is the Bald Hills, an area within Redwood National Park that includes about 1105 ha (2,729 acres) of coastal prairies and 620 ha (1,531 acres) of oak woodlands. This area has a history of occupation and burning by American Indians over the past 4,000 years, followed by a reduction in fire frequency in association with European settlement during the last 150 years. The park currently conducts the majority of its prescribed burns within the Bald Hills in an attempt to restore natural processes in this fire-dependent ecosystem. However, the effects of prescribed burning on this area are not fully understood.

The study approach is twofold. First, the research will experimentally evaluate the effects of prescribed fire on populations of small mammals and reptiles. Objectives are to determine the effects of prescribed fire on population characteristics (e.g., density, survival, and fecundity) of small mammals and reptiles, and to determine how long potential effects last. The second research component will evaluate associations between raptor abundance and burn history (frequency of burns and number of years since last burn) throughout the Bald Hills. The researchers hope to determine whether potential effects on prey populations observed in the first component are influencing habitat use patterns of a major group of predators in the Bald Hills. Focus of the research is on the prairie habitat, the dominant habitat type in the Bald Hills.

Aerial view of Maneze Prairie seven weeks after the three study grids were burned. Each of the three treatment (burned) grids is located near the center of the burned area, and each of the three control (unburned) grids is located to the left of a burned area.

The study is being conducted on Maneze Prairie, an area within the Bald Hills that had not burned in at least the 20 years before this study. In preparation for prescribed burning, personnel from the parks set up rectangular grids (0.4 ha or about 1 acre in size) 80 meters apart. During September 1998, staff burned every other grid in Maneze Prairie, including a buffer strip >40 m wide, resulting in three treatment (burned) and three control (unburned) grids (see photo).

The burn provided an opportunity to obtain short-term movement and mortality information for California voles *(Microtus californicus)*. The researchers radio-collared and tracked 18 adult voles in the three burned grids (6 voles per grid, 3 males and 3 females) before and up to a month after the prescribed fire. They will continue to sample small mammal and reptile populations and vegetation structure and composition four times per year for the next 2–4 years. Analysis of variance procedures will be used to compare changes in population characteristics from pre-treatment to post-treatment sample periods between burned and unburned grids.

The study of association between raptor abundance and burn history was initiated during the winter of 1998–99 and will continue throughout the upcoming years. To calculate an index of raptor abundance, the researchers are conducting standardized roadside counts along the Bald Hills Road. Observations of raptors are marked on a map, and behavioral information (e.g., hovering, flying, perched) is recorded. Frequency analyses will be used to evaluate relationships between raptor abundance and measures of burn history (e.g., burn frequency and number of years since last burn).

Results from the ongoing research will be reported in a future issue of *Park Science* and in journal articles.

CHESAPEAKE

Forest studied at George Washington Birthplace

Marc D. Abrams, Professor of Forest Ecology and Tree Physiology in the School of Forest Resources at Penn State University, recently completed a study of the composition, structure, and dendroecology of a mature loblolly pine-mixed hardwood forest at the George Washington Birthplace National Monument, eastern Virginia. Loblolly pine, sweetgum, holly, blackgum, and several oak species dominate the forest. Blackgum trees dominated recruitment from 1840-1900, based on current age structure. All other tree species are less than 100 years old. A compilation of major and moderate radial growth releases revealed multiple disturbance events in most decades from 1870-1990. A dramatic increase in the radial growth of blackgum occurred in the late 1880s, probably in response to selective logging of pine and hardwood timber species. This disturbance stimulated the recruitment of blackgum followed by loblolly pine and other hardwood species. A decline in blackgum recruitment occurred during the 20th century. The existing loblolly pine range in age from 64-105 years, and this species stopped recruiting in 1935. Seedlings and saplings of all species are scarce, with the exception of holly, a highly shade-tolerant, understory tree species. Loblolly pine trees in the overstory may exhibit future declines because of their relatively short longevity, insect attack, and windthrow. Given current conditions, the future stand composition most certainly will contain less loblolly pine and more hardwoods, including sweetgum, blackgum, and holly.

NEW ENGLAND

Johnson to Rhode Island

The Northeast Region recently hired Elizabeth Johnson, former Chief of Research and Resource Planning at Delaware Water Gap National Recreation Area, as the Regional Inventory and Monitoring Coordinator. Beth will be stationed at the University of Rhode Island on the Kingston campus.

Millennium checkup

The millennium can be a useful milestone to measure progress with the resource stewardship of our national parks. The Northeast Region in conjunction with the George Wright Society and the Conservation Study Institute will host a conference at Valley Forge, Pennsylvania, 19-21 January 2000, which will provide an opportunity to reflect on the region's work, share successful approaches, and prepare for meeting the challenges of stewardship in 2000 and beyond. For more information please refer to the conference website at http://www.portup.com/~gws/ner2000.html. PS

Ecological stewardship works published

The much anticipated, three-volume work *Ecological Stewardship: A Common Reference for Ecosystem Management* (ISBN 0-08-043206-9) is now in print. Published by Elsevier Science (www.elsevier.com) in association with the USDA Forest Service and the World Resources Institute, the three-volume set is the result of work begun in 1995 at the interagency Ecological Stewardship Workshop in Tucson (*Park Science* **16(2)**:13-15). At the workshop, participants detailed plans for documenting the knowledge base and management challenges for implementing ecological stewardship approaches to natural resource management. As a result, 60 papers were drafted and address both the scientific and management aspects of six themes: shifting public values; expectations and law; social and cultural dimensions; humans as agents of ecological change; biological and ecological dimensions; and economic dimensions and information collection and evaluation. Volume I presents key findings and volumes II and III are the full papers. At 1,500 pages, the hardback set costs $250 and includes a CD-ROM.

Also recently published is the USGS report *Status and Trends of the Nation's Biological Resources*. This two-volume set details the issues affecting biological resources and the status and trends of these resources in specific regions of the United States. The full-color report (stock number 024-001-03603-7) contains 1,000 pages of information ranging from descriptions of the natural processes affecting our nation's ecosystems, reasons for the current condition of our natural resources, and discussion of the forces that have the most significant impact on these resources, among other topics. The report is available from the Superintendent of Documents, U.S. Government Printing Office (www.gpo.gov/su_docs/sale.html), for $98.

Deer census methodologies reviewed

The large increase in white-tailed deer numbers in recent decades throughout much of the eastern United States has resulted in an urgent need to determine the size of many deer populations. To assist resource managers and biologists in selecting a census technique suitable for local conditions and a variety of project goals and objectives, authors Allan O'Connell, Jr.[1], Linda Elyse[2], and John Zimmer[3] have published the "Annotated bibliography of methodologies to census, estimate, and monitor the size of white-tailed deer *(Odocoileus virginianus)* populations." The methodologies described in the bibliography include references in the field of sampling techniques, enumerating and estimating biological population size, monitoring trends, and an extensive list of scientific literature in these fields specific to white-tailed deer. A historical account of techniques used to count and estimate the size of deer populations during the 20th century also has been provided. Citations appear in ProCite format (version 4.03) with abstracts and keywords; indexes for keywords and authors have been included to facilitate retrieval of information.

The report was funded through the NPS white-tailed deer research initiative and is published by the NPS Boston Support Office (Technical Report NPS/BSO-RNR/NRTR/00-2, July 1999, NPS D-200). It is available on the World Wide Web in both HTML and PDF formats. To see the report, visit www.pwrc.usgs.gov/library/bibs.htm and click on the title of the bibliography.

[1]Cooperative Park Studies Unit, Patuxent Wildlife Research Center, USGS-BRD, University of Maine, Orono.
[2]Department of Wildlife Ecology, University of Maine, Orono.
[3]Acadia National Park, Bar Harbor, Maine.

Northeast reports available

The Natural Resource Management and Research Office of the NPS Boston Support Office has recently published the following reports:

Schauffler, M., and G. L. Jabobsen, Jr. 2000. Paleoecology of coastal and interior *Picea* (spruce) stands in Maine. Research summary and management recommendation. NPS/BSO/RNR/NRTR/00-1. NPS D-204.

Glanz, W. E., and B. Connery. 2000. Biological inventories of Schoodic and Corea Peninsulas, coastal Maine, 1996. NPS/BSO/RNR/NRTR/00-4. NPS D-199.

Sneddon, L. 1999. Classification of coastal plain pondshore communities of the Cape Cod National Seashore. (Number not assigned as of press time).

Chilelli, M., J. R. Gilbert, B. Griffith, and A. F. O'Connell, Jr. 1998. Analysis of factors affecting population viability and reintroduction attempts of native mammals in Acadia National Park. Technical Report NPS/NESO/RNR/NRTR/98-06. NPS D-191.

Higgins, J., A. F. O'Connell, Jr., and F. A. Servello. 1998. Survey of flying squirrels and their association with vegetation communities on Mt. Desert Island (Acadia National Park), Maine. Technical Report NPS/NESO/RNR/NRTR/98-08. NPS D-194.

Matz, A., J. R. Gilbert, and A. F. O'Connell, Jr. 1998. Acadia's bald eagles: research summary and management recommendations. Natural Resources Report NPS/NESO/RNR/NRTR/98-07. NPS D-192.

The last report listed was funded through the Natural Resources Preservation Program. Eight pages in length, it is a compilation of ecotoxicology and the effects of human disturbance on nesting eagles.

Copies of the reports are available from the Boston Support Office (carol_daye@nps.gov).

Yellowstone bears in print

Staff of Yellowstone National Park and their research colleagues have recently published several professional articles addressing various bear ecology and management issues in the world's first national park:

Consolo Murphy, S., and B. Kaeding. 1998. Fishing Bridge: 25 years of controversy regarding grizzly bear management in Yellowstone National Park. Ursus **10:**385–393.

Gunther, K. A., and H. E. Hoekstra. 1998. Bear-inflicted human injuries in Yellowstone National Park, 1970–1994. Ursus **10:**377–384.

Murphy, K. M., G. S. Felzien, M. G. Hornocker, and T. K. Ruth. 1998. Encounter competition between bears and cougars: some ecological implications. Ursus **10:**55–60.

PRIMENet report out

The First Annual Report (1999) of the Park Research and Intensive Monitoring of Ecosystems Network (PRIMENet) was published in June. The report describes progress at the 14 designated PRIMENet parks

Continued on page 10

Continued from page 9

on establishing research and monitoring of air pollution and UV effects on park resources. Copies of the report, now being reprinted, are available from NPS PRIMENet coordinator Kathy Tonnessen (kathy_tonnessen@nps.gov).

Visibility in the parks

The NPS Air Resource Division and the Cooperative Institute for Research in the Atmosphere (CIRA of Colorado State University) have published "Introduction to Visibility" (ISSN 0737-5352-40). Written by William C. Malm of the National Park Service, the primer examines the nature of visibility problems in the national parks, beginning with a look at the physics of light, its interaction with particles in the atmosphere, and the nature of vision through the atmosphere. The resource is easy to understand, printed in full color, and available from the author (malm@terra.cira.colostate.edu).

Prescribed fire volume released

The Tall Timbers Research Station of Tallahassee, Florida, has published volume 20 in its Tall Timbers Fire Ecology Conference Proceedings series. Entitled, "Fire in Ecosystem Management: Shifting the Paradigm from Suppression to Prescription," the collection of nearly 80 papers recounts the successful conference of the same name (*Park Science* **16**(4):11, 30), which was held in Boise, Idaho, in May 1996. The proceedings (ISSN 0082-1527) cost $40 and are available from the Tall Timbers website (www.talltimbers.org). The full citation of the proceedings is:

Pruden, T. L., and L. A. Brennan. 1998. Fire in ecosystem management: shifting the paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Tallahassee, Florida. 462 pp.

Thesaurus of keywords

Marilyn Ostergren is the NPS coordinator for the Inventory and Monitoring Program's Natural Resource Bibliography Inventory (NRBIB). She has developed a thesaurus of natural resource keywords in conjunction with NRBIB database development at parks. The thesaurus may be useful to anyone who wants to use standardized terminology. Richard Aroksaar is an Automation Specialist with the Columbia-Cascades Support Office and has assisted Marilyn, who is also based at the Seattle office, with converting the original text and Windows help file versions to a set of HTML web pages for use on the Internet. The NRBIB thesaurus is available on the NPS NatureNet website at www.nature.nps.gov/nrbib/a.htm.

Calling all ecological restorationists

The Society for Ecological Restoration is compiling a comprehensive database of ecological restoration expertise. Known as the Ecological Restoration Directory, the integrated database will be available both online and in printed form and will include listings of individuals, organizations, agencies, and businesses in addition to available training programs, workshops, and educational services. All entries will be cross-referenced, making the database easy to use, with the information being updated periodically. The directory is funded by the Plant Conservation Alliance (formerly the Native Plant Conservation Initiative), which is also developing a directory of native plant materials.

Those interested in filling out the restoration expertise questionnaire can do so on-line at www.nps.gov/plants/restore/directory. Alternatively, surveys and additional information are available from Jane Cripps; e-mail: jbcripps@eeb32.biosci.arizona.edu; or 520-626-7201. Questionnaires will be accepted through January 2000.

"Ecoregions" by Bailey

Robert G. Bailey, the USDA Forest Service senior geographer and developer of a well-known ecoregion classification system, has published *Ecoregions,* a work that builds upon his earlier book, *Ecosystem Geography,* to characterize the major ecoregions of the Earth. Numerous photographs of representative ecoregions and outstanding color figures are complemented by two color maps showing the major ecoregions of the continents and of the oceans. This book is a significant contribution to the study and classification of ecosystems. Published by Springer-Verlag New York (www.springer-ny.com/ecology/ecoregions), it is available in both softcover (ISBN 0-387-98311-2; $39.95) and hardcover (ISBN 0-387-98305-8; $79.95), and is 192 pages long.

Genetics & plant restoration

Vegetation restoration and reintroduction of species require careful consideration of genetics (Havens, K. 1998. The genetics of plant restoration: an overview and a surprise. Restoration and Management Notes **16**:68-72). Generalizations based on work with a limited number of species are extremely difficult to make. Yet, generating complete information for every species to be restored is unrealistic. Moreover, time and financial constraints and the sheer magnitude of restoration of plant diversity invariably force practitioners to act on educated guesses. Information from an albeit limited number of studies presented in a symposium about plant population genetics at the Chicago Botanic Garden in October 1997 and several recently published guidelines and case studies on restoration of rare plants provide starting points for restorations and reintroductions.

Reductions in population size or plant density or fragmentation of populations can lead to reductions in genetic variation and accompanying loss of fitness in most plant groups. Loss of genetic variation may be greater in species that once occurred in large, highly outcrossing populations. To prevent such genetic hazards in reintroduced plants, large, genetically diverse populations should be created. Equal number of seeds or plants from each maternal line in newly created populations can decrease inbreeding and increase genetic variation. Propagules must be collected with this goal in mind. Seeds must be collected from a randomly stratified sample of plants, so that they include seeds from individuals of different types (e.g., sizes) and from different types in different locations. Seeds from each maternal plant should be kept separate to not only equalize founder representation in reintroductions, but also, if desirable, to purge the genetic load in some lines. Propagules should be from the same ecoregion and, if known, from the same evolutionary line. Propagules with a high site fidelity may be less important in highly outcrossing species. Hybridization between populations may have been common in the evolution of many species and may have rendered hardier individuals. Whether one wishes to introduce, reintroduce, or augment populations is important in the mixing of propagules. For example, introductions should be made in the historic range, and propagules from a site, if available, are preferable for reintroductions. However, species conservation should prevail over population integrity if the choice is between preservation and integrity of a species.

Social sciences & ecosystem management of national forests

The USDA Forest Service applies ecosystem management to national forests. A research social scientist of the bureau (Allen, S. 1997. A social scientist's view of ecosystem management. Journal of Forestry **95(9)**:48) explains that ecosystem management of the forests exceeds restoration and maintenance of ecosystem functions and provision of goods and services. It expands social services. Ecosystem management of the forests requires increasing the understanding of social and economic systems and their links with biophysical systems, widening the scales of inventories, exploring alternative models of collaboration and decision making, and turning spaces into places. Inventories are made not only of fauna and flora, but also of past and present uses of natural resources, of economic and noneconomic values of such uses, and of people's knowledge and attitudes about national forests. One such inventory was of the social, economic, biological, and physical conditions of the 144-million-acre Columbia Basin to provide managers with information. In ecosystem management of national forests, involvement with public land stakeholders exceeds that required by the National Environmental Policy Act and provides a steady stream of communication with the public for better management of resources by many entities. In its infancy is a plan of having the public identify places and common visions for public land management.

Humans and ecosystem management

Oliver Houck, Professor of Law, directs the Tulane Environment Law Program and works in natural resources, coastal, wildlife, and water pollution control law. He has served as U.S. Attorney in Washington, D.C., and as General Counsel to the National Wildlife Federation. His essay "Are humans part of ecosystems" (Environmental Law **28**:1-14) was derived from his "Distinguished Visitor" lecture at the Northwestern School of Law of Lewis and Clark College. It is a humorous presentation of his perspective of ecosystem management. Obviously, the author contends, humans are part of ecosystems but not their measure. Current government planning is dangerous if it intends to put humans back into the definition of ecosystems and predicates management goals not on a natural system but on human needs and desire. The measuring of ecosystems and management goals must be done by species other than humans. The bottom line is to assess the needs of nonhuman species.

To make his point, the author relates how his beloved dog got into the Puppy Chow, which was in a paper bag behind a door that was inadvertently left open. This dog could chew through tougher material than paper and just about ate herself to death. After the dog and her owners spent an anxious night at the veterinarian, the management of the dog food became more rigorous and was certainly not based on dog desire.

The analogy is that perfectly nice and lovable human beings are over their eyeballs into Puppy Chow all the time: subdivisions in floodplains, shoreline condominiums, and sundry desirable activities that lay thick blankets of smog over beautiful vistas. Needed are flexible systems that keep humans out of the chow. The best measures of ecosystems are representative species that indicate natural conditions. The role of humans is the management of ecosystems and themselves toward this goal.

Dam removal

The 1992 National Inventory of Dams lists more than 75,000 large dams and about 2 million smaller dams in the United States. Dams generate power, provide flood control and water supply, facilitate community development, and create opportunities for recreation. Dams also profoundly change ecological communities and degrade river systems. They turn riverine communities into lacustrine communities. Over time, impoundments create severe water-quality problems due to nutrient enrichment and increased productivity, accumulation of contaminants, and sedimentation with concomitant shallowing. Highly eutrophic conditions can lead to algal blooms and excessive growth of aquatic vegetation. These problems substantially raise the cost of maintenance or rehabilitation. Furthermore, tens of thousands of small dams are old and deteriorating; their repair and removal are expensive. To date, dams have typically been removed for reasons of public safety and prohibitive costs of repair. However, an awareness of the harmful effects of dams on the environment and high cost of repair is increasing, and the restoration of river ecosystems has gained attention.

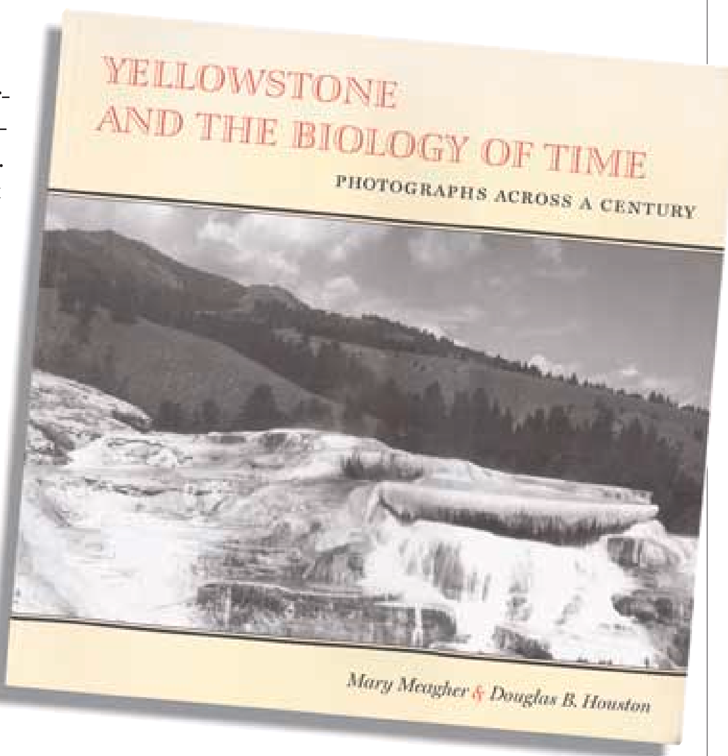
An article published in the journal Environmental Management (Socioeconomic and institutional dimensions of dam removals: The Wisconsin experience. Environmental Management **22(3)**:359-370) reports that more than 30 of 3,600 dams in Wisconsin were removed in the past few decades. It also documents the related legal, financial, and socioeconomic issues associated with the removals.

Community support for dam removal and loss of impoundments is limited. Yet, the estimated cost of repair has been three times higher than the cost of removal. Watershed-scale ecology raises little local interest. Nevertheless, contemporary watershed management and restoration more and more include the option of dam removal. The socioeconomic factors and stakeholder perspectives are variables that strongly influence the viability of management alternatives and must therefore be given more attention. PS

Changing landscapes in the world's first national park

Yellowstone and the Biology of Time: Photographs Across a Century

By Mary Meagher and Douglas B. Houston



A BOOK REVIEW BY DAVID L. PETERSON

"I wish I could have seen this place a hundred years ago." Nearly all of us have uttered that phrase at one time or another, and thanks to a creative photo-filled book, we can now take that step back in time for Yellowstone National Park (Wyoming, Montana, Idaho). *Yellowstone and the Biology of Time* is a landmark volume in the retrospective analysis of parks and protected areas. This chronology of landscape change trumpets the message that ecosystems are dynamic over a wide range of spatial and temporal scales.

Forest Service scientist George Gruell pioneered the use of repeat photography to document ecological change in his classic studies of Montana and Wyoming landscapes published in the early 1980s. Biogeographer Thomas Veblen also used this technique in an interesting analysis of the Colorado Front Range published in 1991. Biologists Mary Meagher and Douglas Houston, both retired federal scientists who spent most of their careers with the National Park Service, follow in this tradition with a heroic effort of repeat photography that provides good spatial coverage of Yellowstone over 120 years.

As Meagher and Houston tell us in the preface, the book had a gestation period of 25 years. They first compiled an impressive collection of photos from the Yellowstone archives, most of which were taken by W. H. Jackson, J. P. Iddings, F. J. Haynes, and J. E. Haynes during the late 1800s. Between 1971 and 1973, they relocated the scenes in the old photos and compiled a new set of photos. A number of logistical difficulties kept them from completing the project, then the fires of 1988 occurred, providing an opportunity to document the effects of large-scale disturbance. So they took another set of photographs. We were fortunate that the authors delayed the publication long enough to capture this critical milestone in ecological time!

The historical photos in *Yellowstone and the Biology of Time* are striking in their beauty and clarity. The cumbersome technology of a century ago must have posed considerable challenge for photographers working in the outdoors, particularly in the backcountry. It is therefore not surprising that many of the photos are adjacent to roads. But that also affords us the opportunity to see the effects of human activities, both historical and contemporary. It is heartening to see the restoration of many sites that were previously heavily grazed by cattle, cut for hay, and used for Army encampments. Conversely we can also see the degradation of modern-day sites by buildings and parking lots.

Brief, descriptive text interprets each photo set with ecological and historical context; on-ground examination of each site by the authors provides helpful information on plant species and other characteristics not apparent to the casual observer. The photos point out dramatic changes in many geothermal features. They also indicate that many of the aquatic systems are surprisingly dynamic in terms of extent, water level, and associated vegetation. Beavers, whose near-elimination has altered the aquatic ecology of Yellowstone, apparently act as a keystone species and may deserve more study with regard to effects that cascade to other species.

The photos also demonstrate that the magnitude of changes in vegetation are extraordinarily site-specific in Yellowstone. Change appears to be relatively fast at many low-elevation sites, but considerably slower at higher elevations (in the absence of fire). Variation in the distribution and abundance of big sagebrush over time is a striking feature in many photos. Reduced cover of quaking aspen and willows, which is cited by some as evidence of "overgrazing" by native ungulates, is apparent in many photos. However, there are also photos that indicate an increase in these species at some locations in the park. The post-fire photos show a mosaic of effects to forest overstory and shrub-steppe species (see the three photos, below).

Photos give way to summaries of the physical and biological framework of Yellowstone, including geology, climate, soil, and vegetation, as well as discussion of the interaction of climate, fire, grazing, and human activities on the dynamics of present-day ecosystems. These sections are rather brief, but they cover the basics. Some readers will be disappointed that the authors do not include detailed discussion of the seemingly endless debates about management of the charismatic megafauna of Yellowstone. Indeed, Meagher and Houston were embroiled in these debates for many years. To their credit, the authors discuss wildlife management and alternative viewpoints even-handedly from a *scientific* perspective. Proponents on any side of current issues related to elk and bison management will not find much fodder for advocacy positions here.

The three photographs of the Tower Junction area, looking east across the Yellowstone River to Junction Butte, document changes in quaking aspen (foreground) from a low, dense stand that was present in 1900 (top photo), to a mature stand in 1972 (middle photo). Taken two years after the 1988 fires, the bottom photo reveals that the large aspen stems were killed by fire. In the background, Douglas-fir and probably big sagebrush increased over the same time period, while aspen declined. The authors conclude that "reduction in fire frequency undoubtedly had a role in vegetative change."

U.S. Army Engineers

D. B. Houston

D. B. Houston

The book has few shortcomings. It would have been nice to see greater consideration of ecosystem dynamics outside the boundary of Yellowstone National Park, particularly given the long-standing existence of interagency assessments and management activities within the greater Yellowstone region. Appendix 2 summarizes temporal changes by vegetation type as seen in photos, but it is not particularly useful due to the high variability between sites. I was also hoping for some better maps, given the ready availability of GIS coverages for Yellowstone.

Yellowstone and the Biology of Time is intended for a general audience. It provides a solid background on basic ecology, natural history, and landscape dynamics for the layperson, and includes sufficient information to hold the interest of those with some technical training in biology. Scientists may be disappointed that the book simply summarizes resource management issues and scientific controversies, rather than shedding much new light on them. The most frequent users of the book will likely be Yellowstone aficionados–those who work in the park, visit it frequently, or otherwise have a strong connection to the park's resources. Fortunately the moderately priced paperbound version will make the book accessible to many readers.

Yellowstone and the Biology of Time...

1998 University of Oklahoma Press
www.ou.edu/oupress

304 pages
287 black-and-white photos,
13 maps, 5 figures, 3 tables, appendixes, notes, bibliography, index

Clothbound
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$80.00

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ISBN 0-8061-3006-7
$32.95

I hope that some enterprising individual will now develop a Web-based archive to provide broader access to this important collection of photos. By having digital images catalogued by topic and geographic location, future photographers–or landscape detectives, as Meagher and Houston call them–will be able to locate particular scenes and add new photos to the archive. All parks and protected areas should consider developing this type of electronic archive, which would be a dynamic information source for scientists, resource managers, and the public.

If you are planning a trip to Yellowstone, buy a copy of *Yellowstone and the Biology of Time.* Read it before you go, then take it with you and note the photo points along the roads and trails. As a modern-day time traveler, you will be able to more fully experience the dynamic Yellowstone landscape. PS

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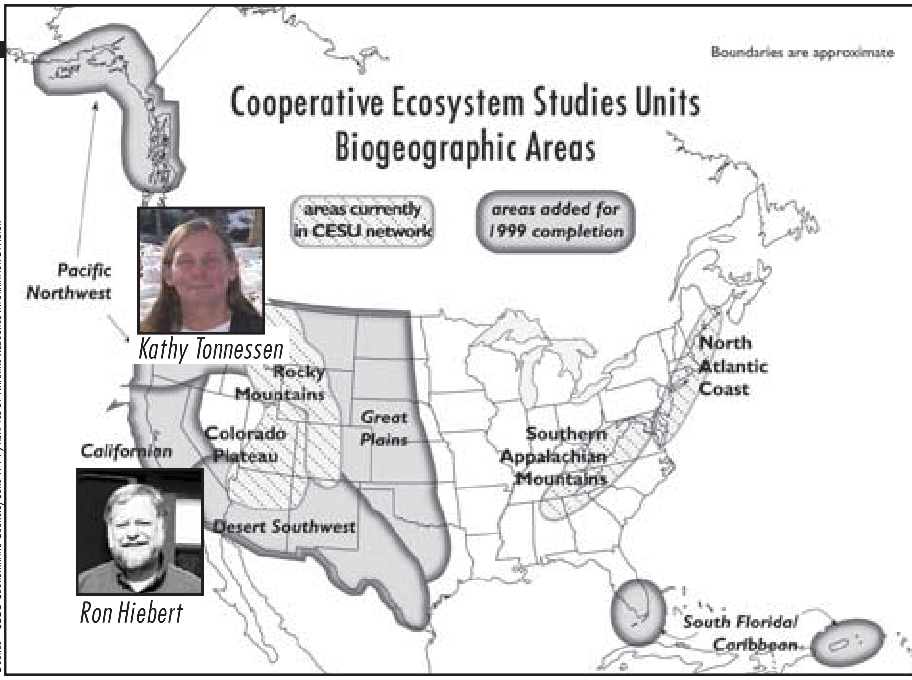

SOURCE—CESU COORDINATING COUNCIL, JUNE 1999; ADAPTED BY NATURAL RESOURCE INFORMATION DIVISION

Figure 1 (map). The CESU network presently includes four biogeographic regions; the website www.cesu.org/cesu describes plans for five additional regions. Kathy Tonnessen (inset, top) is the new NPS research coordinator for the Rocky Mountains CESU and Ron Hiebert (inset, below) fills that role for the Colorado Plateau CESU. These positions are the first to be filled by the National Park Service in support of the new network.

Staffing CESUs in the Intermountain Region

Taking the first steps to success

BY BOB MOON

In an effort to bring this country's brightest talents to bear upon increasingly complex land management issues, the National Park Service has joined with other governmental organizations to craft partnerships with academic and other nongovernmental science institutions that can provide land managers with access to research, technical assistance, and education. Known as cooperative ecosystem studies units (CESUs), these partnerships will provide support in biological, physical, social, and cultural sciences. (Establishment of the CESU network, a list of partners, and a summary of how they function are described on the Web at www.cesu.org/cesu and in the *Natural Resource Year in Review–1998* [pages 27–28]).

In June 1999 the first four cooperative ecosystem studies units became operational: Colorado Plateau, Rocky Mountains, Southern Appalachian Mountains, and North Atlantic Coast (figure 1). Two of these units are within the NPS Intermountain Region and coincide with our Rocky Mountains and Colorado Plateau Clusters.

The Intermountain Region is excited to participate in this new national network of CESUs. With the endorsement of superintendents of the cluster parks, the Intermountain Support Office created two positions to serve as full-time NPS research coordinators to be duty stationed at the host universities: Northern Arizona University for the Colorado Plateau Cluster, and the University of Montana for the Rocky Mountains Cluster. Combined, these two units represent partnerships between five governmental and 14 different partner institutions.

The Intermountain Region is proud to announce the recent selection of Dr. Ron Hiebert (Colorado Plateau) and Dr. Kathy Tonnessen (Rocky Mountains) as our CESU research coordinators (see figure 1 inset photographs). Both will report to their new positions in early December 1999. Many *Park Science* readers already know Ron and Kathy from their current NPS positions.

Ron served for 11 years as Chief Scientist and more recently as Associate Regional Director for Natural Resources for the Midwest Region. No stranger to parks, Ron spent six years as a plant ecologist and Chief of the Division of Science at Indiana Dunes National Lakeshore, Indiana. Ron is equally at home on campuses, having held positions as assistant professor, visiting fellow, and current adjunct professor at the University of Nebraska and Kansas State University. He also brings years of experience working with American Indian education as Chair of the Natural Resource Advisory Board for Haskell Indian Nations University.

Kathy has been Ecologist and Director of Biological Effects in the NPS Air Resources Division since 1991. Before coming to work for the National Park Service, she spent seven years administering air pollution research for the State of California. While there, Kathy designed and implemented field research of natural water geochemistry in Yosemite and Sequoia-Kings Canyon National Parks. Kathy is equally familiar with the university setting, having held affiliated faculty positions with the University of Colorado and Colorado State University.

The focus of the Intermountain Region's involvement in the CESUs will be service to parks and partners. In keeping with this commitment, park managers from each cluster and faculty from each host university participated in the selection processes. Additionally, park managers will participate in development of annual work plan priorities in addition to annual evaluations of the Intermountain Region's CESU research coordinators' accomplishments.

Committees craft cooperatives, which can look great on paper. However, in the end, the talents of individuals assigned to carry out the mission make the difference between success and failure. The Intermountain Region now has commitments from talented managers to support and help ensure the success of these CESUs. With the addition of Ron and Kathy, we are optimistic that these partnerships will flourish. With their help, our parks can expect significant improvement in access to research, technical assistance, and educational opportunities. PS

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Elm yellows

By James L. Sherald, Ph.D.

After successfully withstanding Dutch elm disease for over 50 years, the majestic elms of Washington, D.C., are now facing a new threat. Elm yellows, another systemic and lethal disease, is occurring 50 miles west of the nation's capital. The disease was first detected in eastern West Virginia in 1995, and is now occurring in epidemic proportions along a 75-mile front from Chambersburg, Pennsylvania, to Winchester, Virginia. In addition to the 2,700 elms managed by the National Park Service on the National Mall and throughout the monumental core, the epidemic threatens 9,000 city-street elms, and many other elms on private property. Hundreds of riparian elms along Rock Creek and the Potomac and Anacostia Rivers are also in jeopardy.

Cause of disease

Yellows was first reported in Ohio in 1918, but may have occurred as early as 1880 in Kentucky, Indiana, and Illinois, where elms with yellows-like symptoms were reported. Elm yellows, formerly known as elm phloem necrosis, was believed to be caused by a virus. We now know that it is caused by a phytoplasma. Phytoplasmas are unicellular obligate parasites that, lacking a rigid cell wall, occur in a variety of shapes from spheres to branching filaments. These organisms have not been cultured and are not well understood, yet they are responsible for a number of serious plant diseases including ash yellows, aster yellows, lethal yellowing of palms, pear decline, and X-disease of peach.

The elm yellows phytoplasma is transmitted by the white-banded elm leaf hopper, *Scaphoideus luteolus*, but many other leaf hoppers are probably also capable of transmission. The pathogen occupies the phloem sieve cells–tissue responsible for translocation of photosynthates and hormones–causing abnormal tissue proliferation and death of the current-season phloem.

Symptoms

Infected trees are noticeable by the appearance of bright yellow, drooping leaves (figure 1) in mid to late summer. Symptoms usually affect the entire tree, but sometimes only a portion may show symptoms initially. By the time leaf symptoms are obvious, the fine feeder roots have been destroyed and the tree will die very soon or early the next year. The most obvious diagnostic symptom is the scent of oil of wintergreen (methyl salicylate) that emanates from the inner bark, which has butterscotch to dark brown discoloration.

Five of our six native elms are susceptible to elm yellows: American or white elm *(Ulmus americana);* cedar elm *(U. crassifolia);* red or slippery elm *(U. rubra);* September elm *(U. serotina);* and winged elm *(U. alata)*. The susceptibility of the sixth native elm, the rock elm *(U. thomasii),* is unknown. European and Asiatic elms are only mildly susceptible. They exhibit some leaf discoloration and "witches'-brooms," a common, abnormal growth of small branches caused by other phytoplasmas. The resistance of European and Asiatic elms suggests that the elm yellows phytoplasma, like the Dutch elm disease fungus, is nonnative and probably an introduction from Europe or the Orient.

On the move?

Elm yellows has the habit of quickly reaching epidemic proportions and then subsiding after most of the elms are gone. Until the 1970s, elm yellows was principally found in the Midwest. However, in the 1970s the disease began to appear in the East with outbreaks in New Jersey, New York, and Pennsylvania. Elm yellows has had a devastating effect in communities where Dutch elm disease has been under control. In central New York State, cities such as Syracuse have lost most of their elms. Recently the disease has resurfaced in the Midwest affecting elms in the Chicago suburbs. The current outbreak west of Washington, D.C., is the closest the disease has ever been to the nation's capital.

In 1998, the USDA Forest Service Northeastern Area State and Private Forestry Division conducted an elm yellows survey along the Potomac River following the towpath of the C & O Canal National Historical Park from western Maryland into Washington. Elms are prolific along the Potomac floodplain and may provide an avenue for the disease into Washington.

Figure 1. Bright yellow, drooping leaves and the development of butterscotch-brown inner bark, which has the aroma of oil of wintergreen, are symptoms of elm yellows, a serious disease that affects elms in the midwestern and eastern United States.

Fortunately, no infected trees were seen beyond the general area of infestation 50 miles away. The survey was repeated again in 1999 and no additional infested trees were located. The NPS National Capital Region participates with the Forest Service and the District of Columbia's Tree and Landscape Division in annual Dutch elm disease surveys throughout the city. The disease survey now includes close examination for elm yellows symptoms.

Prognosis

Sanitation, the rapid detection and removal of affected trees, is the only management approach available. Unfortunately, sanitation is not as effective as a management tactic for yellows as it is for Dutch elm disease. Trunk injections with tetracycline can sometimes bring a temporary remission of symptoms, but will not cure infected trees. Plant pathologists continue their search for elms resistant to Dutch elm disease; we are all hopeful that some of those that now show promise will also be resistant to elm yellows. Although the elms account for only 16% of the tree population in the monumental core, their contribution to the landscape is unsurpassed by any other species. Undoubtedly, an elm yellows epidemic would drastically alter the character of the monumental core and much of the landscape of our nation's capital. PS

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DONNA SHAVER

Figure 1 (left). An 11-year-old from the Kemp's Ridley Sea Turtle Project returns to the Gulf of Mexico after laying eggs at Padre Island National Seashore in 1998. Note the living tag on the shell (arrow), on the right side behind the head.

Figure 2 (right, top). National Park Service and U.S. Geological Survey staff release Kemp's ridley sea turtle hatchlings at Padre Island National Seashore. The public and media are encouraged to attend these releases.

Figure 3 (right, bottom). Kemp's ridley sea turtle hatchlings released on the beach at Padre Island National Seashore.

Kemp's ridley sea turtles return to Padre Island National Seashore

BY DONNA J. SHAVER AND JOHN E. MILLER

Projects to restore endangered species typically require years of patience and persistence. After two decades of effort, the project to establish a nesting colony of Kemp's ridley sea turtles *(Lepidochelys kempii)* at Padre Island National Seashore (Texas) is showing signs of success. In 1999, 17 confirmed Kemp's ridley nests were located in the United States, including 11 at Padre Island National Seashore. Sixteen of the 17 nests were located in south Texas, constituting the most Kemp's ridley nests documented on the Texas coast in a single year and an increase in the number of Kemp's ridley nests detected on the Texas coast for the fifth consecutive year (Shaver and Caillouet 1998).

Background

Kemp's ridley is the most critically endangered sea turtle in the world, with only about 3,000–5,000 (TEWG 1998) adults remaining in the population. Most Kemp's ridley sea turtles nest near the village of Rancho Nuevo, Tamaulipas, Mexico. In 1978, it was feared that Kemp's ridley would go extinct within a few years unless immediate steps were taken. An experimental, binational project involving the National Park Service (NPS), National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), Texas Parks and Wildlife Department, and Mexico's Instituto Nacional de la Pesca was undertaken to establish a secondary nesting colony of Kemp's ridley sea turtles at Padre Island National Seashore where nesting had previously been documented (Fletcher 1982; Shaver 1987, 1990, 1992). Scientists and resource managers from a variety of private, state, and federal agencies in the United States and Mexico recognized that establishing a secondary nesting colony would provide a safeguard for the species–if an environmental or political catastrophe were to occur at the primary nesting area in Mexico, an area in the United States would be protected where Kemp's ridleys could nest (Shaver 1990; USFWS and NMFS 1992).

From 1978 through 1988, approximately 2,000 Kemp's ridley eggs were collected each year (totaling 22,507) at Rancho Nuevo and incubated at Padre Island National Seashore. Hatchlings were experimentally imprinted on the beach at the national seashore and then reared in captivity for their first 9–11 months of life (head-started) at the NMFS laboratory in Galveston, Texas. Overall, 13,211 Kemp's ridley turtles from this project were tagged and released into the Gulf of Mexico and adjacent bays as yearlings, in hopes that they would return someday to south Texas to nest. Additionally, 1,097 untagged hatchlings and 300 tagged 2–16 year-old turtles from this project were released.

The first confirmed record of Kemp's ridley nesting in the United States was of an individual that laid eggs at Padre Island National Seashore in 1948, 15 years before it became a national seashore and 30 years before our project to establish a nesting colony began. From 1948-99, 61 Kemp's ridley nests were documented on the Texas coast (Shaver and Caillouet 1998). Additional nests could not be fully documented, while others certainly went unnoticed or unreported both before and after 1948. All 61 confirmed nests were found in south Texas, including 39 at the national seashore. In fact, during the last 50 years, more confirmed Kemp's ridley nests have been located at Padre Island National Seashore than anywhere else in the United States (Shaver and Caillouet 1998). Only eight Kemp's ridley nests have been found at other U.S. locations outside of Texas. Forty-eight of the 61 confirmed Kemp's ridley nests found in Texas were located from 1995–99. These 61 records resulted from turtles and tracks located by the public and, after 1994, by national seashore turtle patrollers. Although personnel from the seashore have been conducting patrols for nesting sea turtles since 1986, these patrols were not very comprehensive until the last two to five years. Thus, the recent increase in detected nesting may reflect increased nesting, improved detection efforts by national seashore turtle patrollers, increased awareness and reporting by the public, or a combination of all of these factors.

Program payoff

In 1996, the first two confirmed returnees from the project nested at Padre Island National Seashore. Through 1999, nine returnees were found nesting in south Texas (Shaver 1996a, 1996b, 1997; Shaver and Caillouet 1998). The returnees were identified by *living tags,* which were used to mark some individuals of the 1982 year-class (year hatched) and all individuals of the 1983–1988 year-classes. Living tags (figure 1) are tissue transplants of a small piece of light-colored plastron (bottom shell) implanted into the darker carapace (top shell). At 10–15 years of age, these turtles found their way back to south Texas, mated, nested at or in proximity to the beach where they were imprinted as hatchlings, and produced clutches containing viable offspring. These returns represented the first confirmed records of sea turtles experimentally imprinted on an area that returned to that area to nest; they are also the first confirmed records of head-started sea turtles nesting outside of captivity (Shaver 1996a, 1996b, 1997).

Before 1985, no turtles from the experimental imprinting and head-starting project that resided outside of captivity would have been mature and able to nest. Thirteen of the 52 confirmed Kemp's ridley nests found on the Texas coast from 1985–1999 were conclusively linked to the project. Although we can not prove it, some of the other 39 nests found from 1985–99 may have originated from the project. This is possible because: (1) Kemp's ridleys from the earliest year-classes were released without living tags and would not have been identifiable as being from the project after just a few years of age, due to shedding of the metal identification tags placed on their flippers; (2) some nesting Kemp's ridleys were observed by beach visitors but were not examined for tags by trained biologists; and (3) some Kemp's ridley nesting observations were detected only from tracks left in the sand by the nesting females, whereas the species was confirmed by examination of the hatchlings.

The species' future

Although the Kemp's ridley population is now showing very promising signs of recovery on Mexican nesting beaches, the numbers are still far below former levels and levels at which the species could be down-listed or delisted (USFWS and NMFS 1992; TEWG 1998). Protection at the nesting beaches and in the marine environment must be continued to ensure that recovery continues. The Kemp's ridleys currently nesting in south Texas are probably a mixture of both returnees and turtles from the wild stock, with some individuals nesting both in Mexico and south Texas. As the Kemp's ridley population continues to increase and more turtles from the experimental project mature, we expect that nesting in south Texas will increase if the turtles survive after they arrive in the area.

Unfortunately, more adult Kemp's ridleys are found washed ashore (stranded) in Texas than in any other U.S. state (Shaver 1999), even though they forage in, and migrate through, near-shore waters of several other U.S. states. From 1995–99, when increased Kemp's ridley nesting was detected on the Texas coast, 88 adult Kemp's ridleys were found stranded on Gulf of Mexico beaches in south Texas; roughly half of these were located within the national seashore. All were found dead or dying; most were likely the victims of accidental capture during fishing activities. Much of this mortality occurred during the Kemp's ridley mating and nesting seasons, and the deaths of adults of the species in south Texas waters likely reduced nesting in this region these years (Shaver 1999).


Anne L. Green

The National Park Service and the U.S. Geological Survey (USGS) do not have jurisdiction over the waters in which the mortality is occurring but are coordinating with other entities to try to reduce these deaths. For example, during 1997 and 1999 we satellite-tracked the movements of 12 adult females that nested in south Texas to delineate areas in which they would be vulnerable to various threats in the marine environment and to help locate subsequent nesting sites.

Because only about one in 200 Kemp's ridley hatchlings survives to adulthood (TEWG 1998) and mortality of adults in south Texas is now relatively high, we must maximize survivorship of eggs laid in south Texas to help ensure the continuation of nesting here. Since beach visitors detect many of the Kemp's ridleys that nest in south Texas, we actively attempt to educate the public about our program through media interviews, educational programs, posters, brochures, and roving beach contacts. One of the most effective means is a semimonthly newspaper column that we write to provide information to locals about various aspects of the turtle program, such as hatchling release dates and other updates. Also, each summer NPS and USGS staff and volunteers search the 80-mile length of North Padre Island (including the 68-mile length of Padre Island National Seashore) via all-terrain vehicles to look for and protect nesting Kemp's ridley sea turtles and their eggs. Virtually all Kemp's ridley eggs detected on the south Texas coast are collected and incubated in a hatchery at the national seashore, and most emerging hatchlings are also released at the seashore (Shaver 1990, 1997 [figures 2 and 3]). Hundreds of visitors and numerous media personnel visit the park to view our hatchling releases each year.

We hope that increasing numbers of critically endangered Kemp's ridley sea turtles will nest at Padre Island National Seashore in the future, helping to ensure the survival of the species. If this occurs, more people will enjoy the opportunity to safely view these rare turtles. Additionally, the project to establish a nesting colony of Kemp's ridley sea turtles at Padre Island National Sea-

At 10-15 years of age, these turtles found their way back to south Texas, mated, nested..., and produced... viable offspring

"Ridleys" cont'd in right column on page 39

Figure 1 (left). Wildlife observation was one factor that shaped visitor attitudes positively regarding the Denali Visitor Transportation System (VTS).
Figure 2 (map). One of five transportation options at Denali National Park and Preserve (Alaska), the VTS operates on an 89-mile gravel road and includes trips from the main park visitor center to Toklat River, Eielson Visitor Center, and Wonder Lake.

An assessment of visitor satisfaction with public transportation services at Denali National Park & Preserve

By Craig A. Miller and R. Gerald Wright

National park system areas are increasingly confronted with problems associated with private vehicle use, and managers at many areas are actively seeking solutions to mitigate the impacts caused by vehicle use including congestion, parking, and potential resource degradation. Denali National Park and Preserve offers a unique example of a management solution directed at resolving traffic congestion, while at the same time maintaining a quality visitor experience and protecting the natural resources of the park. However, although this system has been in place for 25 years, the park administration has had, until the present study, little definitive knowledge regarding visitor attitudes toward and satisfaction with the transportation system. A brief questionnaire survey of visitor opinions toward park transportation policy conducted in 1972 by Harrison (1975) and a similar follow-up personal interview survey conducted by Singer and Beattie (1986) have provided the only insights into visitor attitudes toward the extensive transportation system.

Before 1971, park roads experienced limited private vehicle traffic, as visitors wanting to visit the park in their own vehicles had to travel the difficult, dirt "Denali Highway" connecting Cantwell with the Alaska Highway or ship their vehicles by rail from Anchorage. In late 1971 the George Parks Highway, linking Fairbanks to Anchorage, was completed, providing a direct paved route to the park. Anticipating a substantial increase in vehicle traffic, the park took a proactive approach by closing the park road the following summer to private vehicles past milepost 14. Beyond that point, only those visitors holding campground permits or those traveling to the private inholdings in the Kantishna region were permitted access in private vehicles. A transportation system was developed to replace the use of private vehicles in the park (figure 1).

At the time of its inception, the transportation system in the park was unique among the national parks in the United States and remains so today, as visitor access to the park's interior is controlled. This service, presently known as the Visitor Transportation Service (VTS), is now one of five transportation options available at the park. Two other transportation options are principally booked through private tour companies, while a fourth system is a camper bus that transports backcountry permit holders into and out of the park. The fifth transportation type is a private service that takes visitors to private lodges in the Kantishna region.

The VTS system includes trips to three locations within the park (figure 2). The first of these destinations is the Toklat River, a distance of 53 miles and duration of 6 hours. The second is the Eielson Visitor Center 66 miles into the park an 8-hour round trip. Wonder Lake is the third destination, requiring an 86 mile and 11-hour round trip. Tickets are available at the visitor center or through advanced reservations.

Study Design

We examined visitor satisfaction with the three VTS trips as part of a larger study of all the transportation options within the park. A survey examining visitor attitudes toward the transportation service was conducted in the park during the summer of 1996. Researchers boarded VTS buses before departure from the visitor center, explained the need for the study, and asked visitors to complete the 8-page survey on their return trip. Visitors were asked to rate: the quality of the bus as a means of viewing the park, their satisfaction with the wildlife viewing experience, and perceptions of crowding on the park road. In addition to these questions, visitors were also asked if they had visited Denali or other national park sites before their current trip. The questionnaire also asked for demographic information such as age and gender.

Results

Visitor response to the survey was very favorable. Of the 1,385 visitors using the VTS buses who were asked to participate in the survey, 860 returned usable questionnaires for a response rate of 69%. Spot surveys undertaken by researchers riding the buses at various times indicated that most of the passengers consisted of family groups and that the overall response rate was influenced by the fact that often only one member of a family group returned the questionnaire. Based on this observation, we are reasonably certain that there was probably a minimal non-response bias. Returns from the survey indicate the mean age of VTS passengers was 46, 137 (16%) had visited the park in the past, and 109 (80%) of the visitors who had previously visited the park had used the VTS buses.

Visitors were asked to rate the quality of the bus seating, the bus as a platform for viewing wildlife, the driver's knowledge of the park, and the courtesy of the driver. These results, presented in table 1, show visitors to be satisfied with these aspects of their trip, as the majority of visitors rated each of these items as "good" or "excellent."

In order to assess what factors contributed to visitor satisfaction with the transportation service, the questionnaire asked each passenger to select from lists those items that either contributed to–or detracted from–their satisfaction with their park experience. Visitors responded that the freedom to view the park instead of focusing on driving, driver courtesy, and wildlife observations were each positive factors in providing a satisfactory experience. The responses to those factors that contributed to satisfaction and detracted from visitor satisfaction are presented in table 2.

To examine the effectiveness of the transportation service, the questionnaire asked visitors to respond to the three statements shown in table 3: "The transportation service buses enhanced my visit to Denali National Park;" "seeing buses or other vehicles detracted from my enjoyment of the park;" and "buses and other vehicle traffic interfered with my enjoyment of wildlife." The responses to these statements indicate the majority of visitors using the VTS buses see the buses as an enhancement to their park experience and do not feel the buses interfered with their reason for visiting the park, which was primarily to view wildlife.

Table 1.
Visitor ratings of quality for VTS buses

Item	Poor	Fair	Good	Excellent
		# responses (%)		
Comfort of bus seating (n=855)	13 (2%)	234 (27%)	523 (61%)	85 (10%)
Bus as a place for viewing wildlife (n = 838)	31 (4%)	208 (25%)	431 (51%)	168 (20%)
Driver's knowledge of the park (n = 837)	1 (<1%)	21 (3%)	259 (31%0	556 (66%)
Courtesy of driver (n = 839)	2 (<1%)	6 (<1%)	141 (17)	690 (82%)
Overall quality of transportation service (n = 855)	11 (1%)	85 (10%)	568 (66%)	191 (22%)

Table 2.
Visitor attitudes toward the transportation system

Factors that contributed to visitor satisfaction	Yes	No
Freedom to view park instead of focusing on driving	623 (72%)	110 (28%)
Courtesy of transportation service driver	630 (73%)	230 (27%)
Wildlife observations	749 (87%)	110 (13%)
Factors that detracted from visitor satisfaction	**Yes**	**No**
Uncomfortable ride	67 (8%)	795 (92%)
Traffic on the road	76 (9%)	784 (91%)

Table 3.
Visitor attitudes toward the VTS buses

Statement	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
"The transportation service buses enhanced my visit to Denali National Park"	190 (23%)	466 (56%)	120 (14%)	41 (5%)	15 (2%)
"Seeing buses or other vehicles detracted from my enjoyment of the park"	11 (1%)	84 (10%)	120 (14%)	441 (53%)	176 (21%)
"Buses and other vehicle traffic interfered with my enjoyment of wildlife"	15 (2%)	68 (8%)	114 (14%)	440 (53%)	186 (22%)

Conclusion

The findings of this study indicate that visitors to Denali National Park and Preserve who use the VTS buses are very satisfied with the service. Visitors gave high ratings for the bus as a platform for viewing wildlife, and bus driver courtesy and knowledge of the park. In addition, visitors did not express negative attitudes toward other vehicles encountered in the park. One point of special interest is the ratings given to comfort of the buses. Visitors spend from 6–11 hours on the buses traveling over a gravel road. A negative experience in terms of uncomfortable bus seats could serve to undermine any other efforts to provide the visitor with a quality experience. Visitor satisfaction remains high, despite the length of the tours. Overall, visitors gave the transportation service high approval ratings, with 88% of the visitors rating the service good to excellent.

Denali National Park and Preserve offers an exciting wilderness experience for visitors, and the visitors contacted through our survey indicate that this experience is enhanced by the transportation service. Responses also suggest that this quality experience is to a large extent dependent on the courtesy and knowledge of the bus driver. This is an important consideration, as the visitors spend more time with the driver than any other park personnel. The transportation system in Denali not only allows visitors to experience the wild beauty of the park and its wildlife, but also affords a high degree of resource protection and visitor safety. PS

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Craig Miller conducted the study as a research associate with the Dept. of Fish and Wildlife Resources, University of Idaho. He is now a scientist with the Illinois Natural History Survey in Urbana, Illinois. Gerry Wright is an ecologist with the USGS Idaho Cooperative Fish and Wildlife Research Unit and Professor in the Dept. of Fish and Wildlife Resources at the University of Idaho in Moscow; gwright@uidaho.edu.

"Pecan" continued from cover

and intervention when pest damage thresholds are reached and crop damage is imminent. This limited intervention protects the crop, while minimizing side effects.

IPM and the LBJ pecans

The national historical park represents a special environment for the development and implementation of pecan IPM. This is because the motives underlying conservation of this orchard differ from those of most other pecan operations where profit would represent the bottom line. At the outset, the standard pecan IPM program practiced by producers in the region was presented and discussed with park personnel to determine what could be adopted and what needed to be modified for use. As expected, the major modifications centered on pesticides, with minimizing impact on nontarget organisms emphasized to a greater extent than efficacy or maximizing profitability. The pesticides currently approved for use in the pecan orchard at LBJ National Historical Park are glyphosate for weed management, benomyl and propiconazole for pathogen management, and dormant oil, *Bacillus thuringensis* endotoxins, and carbaryl for insect management.

These pesticides are strategically used to conserve the annual production of pecan nuts in the orchard. The need for these pesticides is best understood by comparing and contrasting the wild pecan with the orchard pecan. The wild pecan grows in mixed-species riverine habitats with tree canopies often touching. Weed control is provided by dense shade, but the close spacing limits available sunlight above and nutrients available to the roots below. Wild pecan trees produce nuts synchronously at 2–7 year intervals (figure 2) and have never been shown to produce sizeable crops in consecutive years. Orchard pecans are vegetatively propagated at deliberately spaced intervals to allow ample sunlight between trees and root development well beyond the canopy of each tree to access water and nutrients. Left unchecked, weeds will readily colonize the orchard floor and outcompete the trees for water and nutrients. Thus, fertilizer is added (nitrogen, phosphorus, potassium, and zinc, as needed) to increase tree vigor and ensure sufficient food reserves are available to produce the current year's crop and establish a crop for the following year.

An integrated pest management plan has been developed at the park to allow the orchard to be agriculturally productive

Natural enemies

Wild pecans survive pathogens through many mechanisms of which one of the most important is genetic diversity. Every wild pecan tree is genetically distinct from its neighbors. Pecan scab, a fungus and the worst disease of the orchard pecan, may become genetically entrained to attack specific genetic constructs. Additionally, vegetative propagation of orchard trees provides genetic uniformity that results in potential for disease epidemics. Disease development requires a susceptible host, a virulent pathogen, and a favorable environment. The relatively dry environment at the park limits the favorable environment for pecan scab to brief periods following rains when rapid leaf growth is occurring in the spring or nut growth is occurring shortly thereafter. Fungicide is needed under such conditions to prevent pecan scab epidemics.

Wild pecans survive insect depredations through many mechanisms, too. Foliage and root feeders are generally limited by natural enemies, the environment, and the intrinsic ability of the pecan to resist or recover from attack. Indeed, damage from insects is rare. However, careful monitoring is needed to detect and respond to these rare occurrences, if sustained nut production is to be achieved. Insects that feed on nuts are another matter. Recent research shows that the wild pecan survives the ravages of nut feeders in nature by producing a big crop followed by low production for one or more years. This "boom and bust" cycling of production starves nut feeders to low levels during bust years and produces so many nuts in boom years that nut feeders are satiated long before the big crop is consumed. The nuts left over survive to germinate the following year.

Figure 2. This pecan cluster represents a boom year for wild pecan trees, which occurs at 2–7 year intervals. In contrast, orchard pecans at the park are managed for continual production, and are fertilized and managed in other ways to ensure annual productivity.

Once in awhile a nut will survive to become a tree and form the beginning of the next pecan generation.

The pecan is not perfect in regulating this boom and bust production. Trees on especially good sites, where branches may have better access to sunlight, for example, have extra food reserves. These individuals produce enough flowers to yield up to 10% of a crop in a bust year, even though the remaining trees remain barren. If these pecan flowers continued to grow to maturity, late-season nut feeders like jays, squirrels, and especially the pecan weevil, *Curculio caryae* (Horn) (Coleoptera: Curculionidae), would use them to grow and reproduce, and their progeny would occur in much greater numbers to consume the boom year crop. However, the pecan nut casebearer, *Acrobasis nuxvorella* Nuenzig (Lepidoptera: Pyralidae), attacks nuts just after pollination and removes almost all the nutlets in years of low production. This leaves few nuts to mature in bust years. In years of high production, a similar amount of nutlets (2–10%) is removed by the casebearer, although this has little effect on the boom crop.

This competition between late-season nut feeders and the casebearer works great in nature, preserving the boom-bust cycle in the wild trees, but the pecan grower strives to produce nuts every year by keeping trees well spaced, watered, and fertilized. This practice increases pecan nut production in the orchard. Unfortunately, the pecan nut casebearer comes from nearby wild trees to this pocket of productivity and causes severe

Figure 3. An insect trap dangles from the branch of an orchard pecan and is indicative of the park's ongoing monitoring program for the casebearer moth. A forager of pecans when they are developing in the flower, the casebearer can severely damage the orchard pecan crop in years when wild trees have little or no production.

Figure 4. Insect traps of a different design are used by resource managers to track changes in the population of the pecan weevil. Although this insect species can potentially damage an orchard pecan crop of mature nuts, its numbers have not yet been of concern to resource managers.

damage in the orchard in years when the wild trees have little or no production. The park IPM plan prescribes monitoring for casebearer activity in the orchard using a pheromone (figure 3). If damaging numbers of the casebearer occur, as determined by using a sequential sampling plan, a well-timed treatment with *Bacillus thuringiensis* endotoxin is recommended to conserve agricultural production. This also means abundant nuts will occur in the orchard in the fall when surrounding wild trees are barren. These nuts will often require protection from late-season nut feeders like the pecan weevil. Monitoring protocols have also been developed for the weevil (figure 4) to ensure that action to reduce their numbers is only taken when needed. If treatment is required, the least intrusive, but still effective, management possible is used. However, pecan weevil densities have not built up sufficiently to warrant treatment, despite the species' presence in the orchard.

A groundwater monitoring protocol has also been established in the park to detect runoff or leaching of pesticides used in the pecan IPM program. No runoff has been detected, and the minimal levels of chemical intervention are not expected to cause such problems. Insecticide use, for example, is never expected to require more than 21 days of pesticide protection on the foliage in a growing season of 220+ days. Additionally, the chemicals used are neither biologically magnified nor readily leached through soil. Plus, they are biodegradable. Routine water monitoring is an additional precaution designed to provide the highest quality of stewardship possible.

Conclusion

According to Brison (1974), the pecan is the most important horticultural crop native to the United States. Lyndon B. Johnson National Historical Park provides a setting for the public to enjoy the pecan in all its glory from the wild trees along the Pedernales River, to the semi-domesticated cattle and pecan environs reminiscent of the early 20th century, to the responsibly managed pecan orchard of today and the future. Most of the agriculturally important crops grown in the United States today originated elsewhere. The pecan is ours, and the opportunity to see the entire range of the pecan domestication process is a special legacy indeed.

The pecan at LBJ National Historical Park is a microcosm of the issues and responsibilities facing the National Park Service today. In and near the park, the wild pecan reflects nature preserved in a pristine form, inspiring us as only nature can. The thinned, native pecans show agricultural inroads into nature in order to produce more human-valued, physical resources like nuts and cattle to support more people than the same land could in Cabeza de Vaca's time. The managed pecan orchard shows responsible pecan production that optimizes availability of the human-valued nut resources using the Pecan IPM Plan. Our society needs food for thought as well as food for survival. The pecans at LBJ National Historical Park can help inform and engage the public in addressing these issues.

Routine water monitoring is an additional precaution designed to provide the highest quality of stewardship possible

Acknowledgments

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Figure 1 (left). Built for horse-drawn carriages in the early 1900s, the well-engineered, gravel carriage roads of Acadia National Park (Maine) are very popular among bicyclists and hikers today, creating the potential for crowding and conflict.

Figures 2 and 3 (right, far right). Visitors participating in the social carrying capacity study were asked to rate the acceptability of scenes depicted in 19 computer-generated photos, including these, that illustrated varying numbers and types of carriage road use. These photographs show a typical viewscape on the carriage roads—approximately 100 meters in length.

Crowding and conflict on the carriage roads of Acadia National Park:

An application of the Visitor Experience Resource Protection framework

By Charles Jacobi and Dr. Robert Manning

The carriage roads of Acadia National Park are a unique system of more than 50 miles of beautifully designed and highly engineered gravel roads built under the direction of John D. Rockefeller, Jr., in the early 1900s (figure 1). Although the roads were built for horse-drawn carriages, they are now used mainly by bicyclists and walkers, providing a welcome escape from automobile traffic and access to many undeveloped areas of the park. Equestrian use is low. Longtime observers agree that carriage road use increased greatly with the rise in popularity of the mountain bike in the 1980s, although no data on carriage road use were collected during this time period. However, the park fielded an increasing number of complaints from visitors and area residents during this time about "crowding" and "conflict" on the carriage roads.

In response to these threats to the quality of the visitor experience, park managers decided to apply the Visitor Experience Resource Protection (VERP) framework to carriage road use (National Park Service 1997). VERP addresses carrying capacity and visitor use management of national park areas through nine elements in a generally linear but also iterative process. VERP is one of several frameworks that provide a logical and rational basis for decision-making, and it is becoming more commonly used throughout the national park system.

The VERP framework can also include a natural or cultural resource component for determining carrying capacity. However, we determined that resource impacts at Acadia were minimal. Social trails, erosion, and trampling of vegetation are potential natural resource problems, especially around bridges, ponds, and viewpoints. However, bicyclists, the main users of the carriage roads, are not now causing these problems. Bicyclists are also not using the carriage roads to access hiking trails (biking is not allowed on hiking trails) and thus adding to trail erosion. Nesting peregrine falcons were located well above the carriage road at Jordan Pond and their productivity suggests they were not affected by visitor use. Although the park does not formally monitor natural resources adjacent to the carriage roads, the best professional judgment of park staff was that current impacts were not significant enough to warrant a natural resource component to the carrying capacity process.

As long as the carriage roads are properly maintained (a private endowment now ensures this) visitor use is also unlikely to degrade the road or the bridges (the cultural resource). Only increased equestrian use might pose a threat, and only then if road maintenance is unable to keep up with damage caused by horse use. Thus, this application of VERP is limited to social science and the visitor experience. Through VERP, park managers sought to understand, define, and maintain high quality experiences on the carriage roads.

Park staff received training in applying VERP through a three-day workshop conducted by Marilyn Hof of the NPS Denver Service Center. Based on this workshop, we recognized that more information about carriage road use and users was needed. A three-phase research program was planned, and Dr. Robert Manning of the University of Vermont served as lead investigator.

This paper describes the application of the VERP framework to carriage road visitor use. It begins with a brief description of the supporting research program, and then outlines the application according to the nine elements of the VERP framework[1].

Research program

Phase I

Phase I research was designed to identify potential indicators of quality for the carriage road experience through a survey (questionnaire) of carriage road visitors and

[1]This application started with an earlier draft version of VERP consisting of nine steps that are slightly different than the nine elements in the latest version (National Park Service 1997). The team continued to follow the nine steps of the earlier version of VERP and they are referred to as steps in this paper.

focus group sessions with representatives of major user groups (Manning et al. 1996a; Stillwater Assoc. 1995). Indicators of quality are specific, measurable variables that are important in determining the quality of park resources and visitor experiences. Study findings suggested that most carriage road visitors enjoyed their experience.

However, visitors also suggested that problems with too many people using the carriage roads were emerging, and that selected behaviors experienced on the carriage roads were a problem. These variables–crowding and problem behaviors–were selected as the best indicators of a quality visitor experience. Estimates of visitor use levels using electronic trail counters and a census of carriage road use were also conducted as part of phase I research.

Phase II

Phase II research focused on identifying *standards of quality* for crowding and problem behaviors (Manning et al. 1998a; Manning et al. 1999). Standards of quality define the minimal acceptable condition of indicator variables (Manning, et al. 1996c). Research indicates that visitors often have normative standards concerning acceptable conditions in parks and related areas (e.g., Vaske et al. 1986; Shelby and Heberlein 1986; Hof et al. 1994; Manning et al. 1996b; Manning et al. 1996c). Thus, we administered a second survey to carriage road visitors to determine standards of quality for crowding and problem behaviors.

We identified crowding norms using numerical and visual methods. In the visual approach, a representative sample of carriage road visitors rated the acceptability of 19 computer-generated photos of carriage road use. These photos illustrated varying numbers (0-30) and types (hikers and bikers) of carriage road visitors. Sample photos are shown in figures 2 and 3. The viewscape in the photos represented a typical 100-meter carriage road segment. In the numerical approach, visitors reported the maximum number of people they would find acceptable to see at one time (per viewscape) on the carriage roads. The number of persons-per-viewscape (PPV) then became the measure for crowding and eventual standards of quality. Study findings suggested the maximum acceptable PPV ranged from 11 to 18 based on the various numerical or visual methods used. Visitors reported they now typically see about 5 PPV, suggesting that the carriage roads have not yet reached carrying capacity. Visitors also reported that they would accept seeing the maximum PPV level for about 40% of their visit. This temporal element of crowding norms was a new element of research, and it was addressed more fully in Phase III.

We also developed numerical norms for the four most important problem behaviors–bicycles passing from behind without warning, excessive bicycle speed, obstructing the road, and dogs off leash–from visitor surveys. Visitors reported that existing conditions were close to exceeding their maximum level of acceptability for only one behavior (obstructing the road).

We continued to estimate visitor use with trail counters and censuses in phase II and also developed a computer-based simulation model (see sidebar at end of article on page 26) of carriage road use. Daily carriage road use in the summer of 1995 ranged between 1,000 and 2,000 visitors. These daily estimates can be used as the primary input for the simulation model. For any total use level, the model estimates the number of minutes visitors see various PPVs, informing managers when standards of quality are violated.

Phase III

In phase III research, a representative sample of residents of surrounding communities was asked about their standards of quality using the same questions as phase II research (Manning et al 1998b). Residents also rated the quality of five hypothetical one-hour carriage road visits representing different total carriage road use levels (table 1). These scenarios were developed using the simulation model, and were designed to measure the temporal component of crowding norms in a more detailed way than was done in Phase II research. For comparison purposes, another representative sample of carriage road *visitors* also rated the same five scenarios. Residents were also asked how they had changed their carriage road use over the past several years because of increased use and problem behaviors. Concern about displacement of longtime users was a major reason for administering a survey to local residents.

Findings showed residents have adjusted their personal carriage road use substantially in recent years because of the changes in overall carriage road use. These adjustments include using the carriage roads less often, and shifting use to less-used times and places. Acceptability ratings of both residents and visitors for the five scenarios

Table 1.
Average number of minutes per hour visitors see selected numbers of persons per viewscape (PPV) for five carriage road total use scenarios

PPV	Scenario 1 Total Use=750	Scenario 2 Total Use=1,500	Scenario 3 Total Use=3,000	Scenario 4 Total Use=6,000	Scenario 5 Total Use=12,000
0	55	48	40	28	17
1-5	5	11	18	26	28
6-10	0	1	2	5	10
11-15	0	0	0	1	3
16-20	0	0	0	0	1
21-30	0	0	0	0	1

"Carriage Roads" continued on page 24

"Carriage Roads" continued from page 23

are shown in figure 4. These data suggest that at current use levels, most visitors are having a high quality experience.

However, visitor and resident standards of acceptability for the four problem behaviors differed significantly. Residents were considerably less tolerant of problem behaviors than were visitors. This may be because most residents are walkers and most visitors are bikers. Residents reported that existing conditions of these behaviors are very close to violating their standards of quality.

Application of VERP

Step 1 of the VERP framework calls for appointment of an interdisciplinary planning and management team. The VERP team for the carriage roads included the superintendent, deputy superintendent, several division chiefs, a recreation specialist (team leader), and supervisor of carriage road rovers (interpretive ranger). Marilyn Hof and Robert Manning served as consultants to the team.

Steps 2-3 of the VERP framework prompted a statement of purpose and significance for the carriage roads and the production of maps of resource and social conditions on the roads. This was important because the carriage road system is set amidst a great diversity of natural resources, and use levels and patterns on the roads are also diverse.

In *step 4,* a range of appropriate resource and social conditions was considered for the carriage roads. As already discussed, no natural or cultural resource issues were considered to be significant, although the potential for them exists. Thus, we focused on social conditions only for this application of VERP. In step 4, we also established the major carriage road management goals: shared recreation use of the carriage roads by all types of visitors, a diversity of experiences based on visitor use levels and behaviors, and a high quality visitor experience.

The VERP team zoned the carriage road system in *step 5* and established peak and nonpeak zones based on existing levels and patterns of use. Zones were defined by location, time of day, and time of year.[2] We decided to use the same *indicators of quality* for each zone, but we set different *standards of quality*.

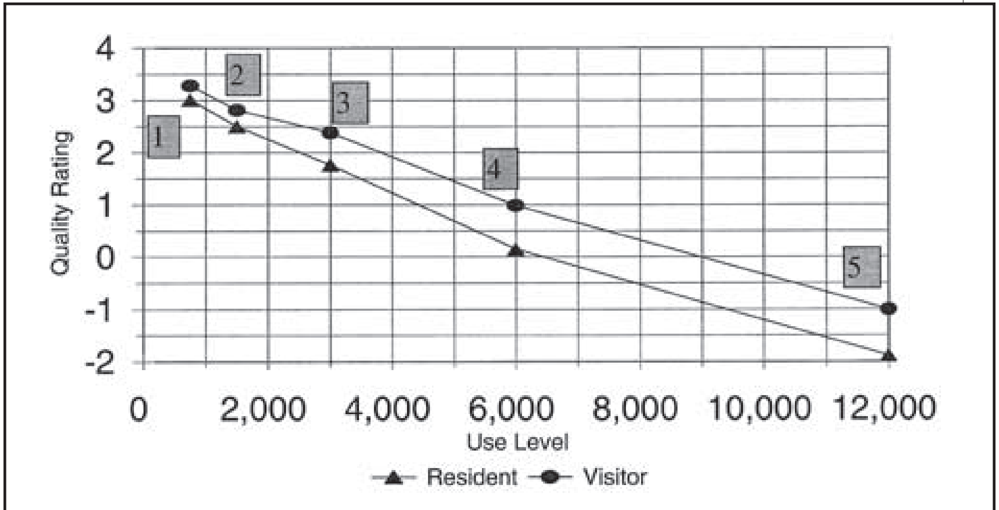

Figure 4. Resident and visitor acceptability (quality) ratings for the five visitor use scenarios were very similar, indicating there was little difference in tolerance for crowding.

Table 2.
Percent of visitors experiencing selected quality ratings (or higher) for selected total carriage road use levels

Carriage Road Use Level (people/day)	Quality Rating 1	Quality Rating 2	Quality Rating 3
1,500	91	85.7	74.2
2,000	91.2	83.4	68.6
2,500	91.5	81.2	62.9
3,000	91.7	**79** (quality standard)	57.2
3,500	87.2	73.5	51.7
4,000	82.8	68.1	46
4,500	78.4	62.7	40.3
5,000	74	57.3	34.6
5,500	69.6	51.9	28.9
6,000	65.2	46.5	23.2

Table 3.
Average number of minutes per hour visitors see selected numbers of persons per viewscape (PPV) in peak and nonpeak zones for four total carriage road use levels

Carriage Road Total Use Level (people per day)	Use=2,500		Use=3,000		Use=3,500		Use=4,000	
PPV	Nonpeak	Peak	Nonpeak	Peak	Nonpeak	Peak	Nonpeak	Peak
0	50	36	48	31	45	29	45	26
1-5	9	22	11	27	14	28	14	29
6-10	1	2	1	2	1	3	1	4
11-15	0	0	0	0	0	0	0	1
16-20	0	0	0	0	0	0	0	0
21-30	0	0	0	0	0	0	0	0

[2]The following three conditions *occurring together* defined the peak zone: a location between intersections 1 and 10 and between 14 and 17, a time between 10:00 a.m. and 5:00 p.m., and a day between June 20 and Labor Day or any of the three days of the Memorial Day and Columbus Day holidays. All other times and places were in the nonpeak zone. Thus, even on July 4, if someone were biking between intersections 1 and 10 after 5:00 p.m., they would be in the nonpeak zone.

Step 6 required formulating standards of quality for each zone. Study findings from the research described earlier were used to help set standards of quality for crowding and problem behaviors. These findings and the standards are outlined here.

Crowding standards

Formulation of crowding standards relied heavily on visitor and resident norms and findings from the computer simulation model. Table 2, developed from the frequency distributions of visitor acceptability ratings of the five carriage road use scenarios, shows the percent of visitors experiencing selected quality ratings (or higher) for selected carriage road total use levels. These data show the relationship between quality and total use, and empirically represent the trade-offs inherent in managing the carriage roads.

While the data in table 2 were helpful, they raised two challenging questions. What quality rating should the park manage for (i.e., what point on the y-axis in figure 4 should be selected)? What percentage of visitors should have an experience of that quality rating or higher? Insight into answering these questions was provided through development of table 3. This table shows computer simulation estimates of PPVs for the peak and nonpeak zones for a range of four likely use levels. For all four use levels, a wide difference exists between the peak and nonpeak zones for the number of minutes visitors see 0 and 1-5 PPV. Establishing and maintaining this diversity of use conditions was a goal set in step 4.

Based on research findings as reported in the tables and figures, the VERP team established three crowding-related standards of quality:

1. Eighty percent of visitors should have a high quality experience (defined as quality rating 2 or higher from table 2). This standard of quality is consistent with the management goal of providing a high quality visitor experience as defined in step 4 of the VERP framework.
2. Total use for the carriage roads should not exceed 3,000 visitors per day. This figure is taken from table 2, which indicates that roughly 80% of visitors have an experience of quality rating 2 or higher at this use level.
3. PPV-related standards of quality for peak and nonpeak zones are as follows:

Total use for the carriage roads should not exceed 3,000 visitors per day

- In the *peak zone,* visitors should see 0 PPV *at least* 31 minutes out of each hour; 1-5 PPV *no more than* 27 minutes of each hour, 6-10 PPV *no more than* 2 minutes out of each hour, and never more than 10 PPV.
- In the *nonpeak zone,* visitors should see 0 PPV *at least* 48 minutes out of each hour; 1-5 PPV *no more than* 11 minutes of each hour, 6-10 PPV *no more than* 1 minute out of each hour, and never more than 10 PPV.

These figures are taken from table 3, which shows PPV estimates for a total carriage road use level of 3,000 visitors per day.

Formulation of standards of quality for crowding and other indicators of quality will always involve an element of value judgment by park managers. However, these research findings, along with the decisions made within the context of the VERP framework, provide an informed, empirical, and defensible basis for such decisions.

Behavior standards

Standards of quality for problem behaviors were established by using the norms described earlier and by trying to balance the divergence in such norms between residents and visitors. Based on this analysis, the VERP team established the following behavior-related standards of quality.

For a two-hour visit in the peak zone, visitors should experience no more than:

- Two instances of bicyclists traveling at excessive speed
- Two instances of bicyclists passing from behind without warning
- One instance of visitors obstructing the road
- Zero instances of dogs off leash

For a two-hour visit in the nonpeak zone, visitors should experience no more than:

- One instance of bicyclists traveling at excessive speed
- One instance of bicyclists passing from behind without warning
- One instance of visitors obstructing the road
- Zero instances of dogs off leash

Step 7 of the VERP framework requires monitoring of indicators of quality. Monitoring of crowding-related indicators of quality will rely on the computer-based simulation model and estimations of systemwide use derived from the electronic trail counter. If estimations of systemwide use exceed 3,000 visitors per day, PPV standards are assumed to be violated. Some direct counts of PPVs will be made as a field-check on the simulation model. Monitoring of behavior-related indicators of quality will be accomplished by administering brief surveys, identical to those used in phase II research, conducted once every three years. Based on monitoring results, crowding standards were not violated in 1997 or 1998. The highest daily use, however, was nearly 2,800 visitors. Behavior standards were not violated in 1997; they will be monitored again in 2000.

Assumptions and conditions on which the simulation model was built must also be monitored for changes. Major changes in use patterns, such as an increase in the number of one-way trips taken, might require adjustment of the model.

If monitoring determines that standards of quality are violated, then *step 8* requires analysis of the root cause of such discrepancies. Research and monitoring suggest that current use of the carriage roads meets all standards of quality. However, the VERP team has considered potential causes of such discrepancies. A new transportation system for the park and surrounding communities began in 1999. Visitor use of this transportation system may change visitor use patterns on the carriage roads enough to cause standards of quality to be violated. The park must preserve the quality of the carriage road experience by managing the transportation system schedule (access) to the carriage roads. Parking enforcement, changing visitor demographics, increased use, a new visitor use, or a failure or lapse in visitor education are also potential causes of discrepancies.

Step 9 requires management action to address any discrepancies between existing conditions and standards of quality. Again, no such discrepancies currently ex-

"Carriage Roads" continued on page 26

"Carriage Roads" continued from page 25

ist on the carriage roads. However, in phase II and phase III research, visitors and residents were asked the degree to which they supported or opposed a range of possible management actions. Based on these findings, the VERP team has identified four potential management actions in decreasing order of priority: further visitor education, parking control and mass transit, visitor permits, and enforcement patrols.

Conclusions and recommendations

VERP provided a systematic, rational, and, where possible, empirically based approach to developing a management plan for the carriage roads. Carriage road experiences were defined through indicators and standards of quality. Indicators of quality will be monitored to ensure that standards of quality are not violated. Finally, a series of management actions is available if and when needed.

Successful application of VERP was due to: (1) obtaining research funding thanks to the relatively high profile of the issue; (2) a peer-reviewed research program that allowed for informed decision-making; (3) thinking ahead about how monitoring would be accomplished; and (4) the dedication of the VERP team.

Several recommendations for applying VERP emerged from our experience. Moving fast was sometimes helpful, especially through steps 1-3. It also helped to push the application as far as possible and recycle through it often; VERP should be considered an iterative process with many feedback loops. The VERP team struggled with steps 4 and 5, and preferred not to dwell on them when they could be revisited. Furthermore, reliable, quantitative information based on peer-reviewed research was critical to the process. Finally, for the purposes of monitoring, the application should be kept as simple as possible. Fewer indicators, standards, and zones make monitoring more feasible.

Park managers now have a sound understanding of carriage road visitor use issues and a plan for managing the visitor experience. A carrying capacity has been established and monitoring is in place. Management challenges lie ahead as the park tries to maintain a high quality carriage road experience.

Acknowledgments

We extend our thanks to Bill Valliere and Ben Wang, research staff at the University of Vermont, for their help in this project, and to Dave Lime, University of Minnesota, and Wayne Freimund, University of Montana, for their help in study design. PS

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Computer simulation model

A computer-based simulation model of carriage road visitor use was developed using the simulation software package Extend by Imagine That, Inc. (Manning et al 1998a, Manning and Wang, 1999). Model inputs came from visitor surveys and census results. Phase II visitor surveys provided information about visitor types, group sizes, and travel routes. Six censuses of carriage road use conducted from 9:00 a.m. to 6:00 p.m. at 11 major access points provided data on carriage road entries distributed in time and space. The model was verified through sensitivity analysis and comparison with data on actual carriage road use. Model output can take several forms, including density of use, numbers of encounters between visitors, and persons-per-viewscape (PPV). For the application of VERP described in this paper, PPV proved to be useful. PPV indicates the number of visitors within any 100-meter viewscape, the approximate typical distance that can be seen along the carriage roads. For any daily total use level of the carriage roads, the model estimates the number of minutes out of an hour that selected PPVs occur. Examples of these data are shown in tables 1 and 3. These data helped formulate standards of quality for the carriage roads. The simulation model can also assist with monitoring indicators of quality. Finally, the model can be a useful management tool by predicting the effect on PPV levels of changes in spatial and temporal use patterns.

Rare plant survey at Capitol Reef National Park

By Deborah Clark and Thomas O. Clark

In 1997 and 1998, Capitol Reef National Park received a research and inventory grant from the National Park Foundation and Canon U.S.A., Inc., through their "Expedition into the Parks" program. This grant enabled National Park Service staff, researchers, and volunteers to collect critical data on several of the rarest plants occurring in the park.

Capitol Reef National Park is located in south-central Utah (figure 1), in the Colorado Plateau region, 72 km (45 mi) west of Hanksville on U.S. Highway 24. It was established to protect the longest exposed monocline in North America and is approximately 97,000 ha (241,903 acres) in size. This wrinkle in the earth's crust runs about 160 km (100 mi) north to south and is named the Waterpocket Fold. Unique geological conditions within the fold have created microhabitats that support over 40 rare and endemic plant species.

The six plant species selected for this study were ones most likely to be impacted by increased park visitation around the headquarters or Fruita area. Capitol Reef is primarily a backcountry park and receives about three-quarters of a million visitors each year. Many of these visitors hike the trails within the Fruita area and many of these trails have rare plant populations adjacent to them. Therefore, information on the whereabouts of rare plants in these high use areas and whether they are being affected by visitation is essential for park management.

Three of the six species are federally listed as endangered or threatened: Barneby reed-mustard (*Schoencrambe barnebyi*–endangered), Maguire's daisy (*Erigeron maguirei*–threatened), and Wright's fishhook cactus (*Sclerocactus wrightiae*–endangered). One species, Rabbit Valley gilia (*Gilia caespitosa*–figure 2), was a candidate for federal listing, but is now being managed under a conservation agreement and strategy that precludes the need to list it[1]. The remaining two species are NPS sensitive: Harrison's milkvetch *(Astragalus harrisonii)*, occurring only within Capitol Reef National Park, and pinnate spring-parsley *(Cymopterus beckii)*.

[1]The conservation agreement and strategy was written by BLM, FWS, USFS, and NPS staff in 1996. This agreement addresses protection measures designed to achieve long-term conservation of the species so that listing under the Endangered Species Act would not be necessary.

The study

The primary purposes of this project were to (1) conduct intensive surveys for the target species within the heavily visited Fruita area, and (2) develop monitoring protocols for each species that would detect changes in plant numbers due to visitor impacts. The study area encompassed approximately 10,000 ha (25,000 acres), with about 6,400 ha (16,000 acres) containing suitable habitat for one or more of the target species (figure 3, page 28). Particular emphasis was focused on areas currently being impacted by visitors and on areas where future increased use is expected.

The study began during the 1997 field season when the interagency botanist mapped known locations using a global positioning system (GPS). These locations were entered into the geographic information system (GIS) and were overlaid with soil types, geologic formations, slope, aspect, and elevations to create a profile of potential habitat by species. In addition to accurately depicting known and potential habitats, this refined the range of each of the six species and helped resource managers plan how many people would be needed to accomplish the tasks.

After completing this initial work, field crews conducted surveys in potential habitat for each species (figure 4, page 28). By surveying from April through late June when the majority of plants were in full bloom crews ensured proper plant identification and increased survey accuracy. Each area was systematically surveyed both by walking transects through all accessible areas and by using binoculars to search cliffs. The crews hiked every established hiking trail and other well-used foot route in the Fruita study area during the appropriate blooming time for each species. If a trail or route passed through potential habitat for two or more species and those species bloomed at different times, then those trails and routes were hiked multiple times to ensure surveys were as thorough as possible for each species. Once all maintained trails were surveyed, then routes and areas receiving off-trail use were surveyed. For future reference, crews noted on maps all areas surveyed.

Figure 1. Capitol Reef National Park is located in south-central Utah and encompasses the Waterpocket Fold, a 100-mile-long geologic formation known as a monocline that provides numerous microhabitats for rare plants.

For each new occurrence of a species, crews completed a modified version the Utah Natural Heritage Division Site Visit Account Survey Form, took photographs, and mapped its location on 7.5' quadrangle maps. Wherever possible, a GPS was used to map the precise location of each new occurrence.

Localities found on or adjacent to hiking trails and routes were recorded and

Figure 2. Rabbit Valley gilia, a candidate for federal listing, is now being managed under a conservation agreement and strategy.

"Plant Survey" continued on page 28

"Plant Survey" continued from page 27

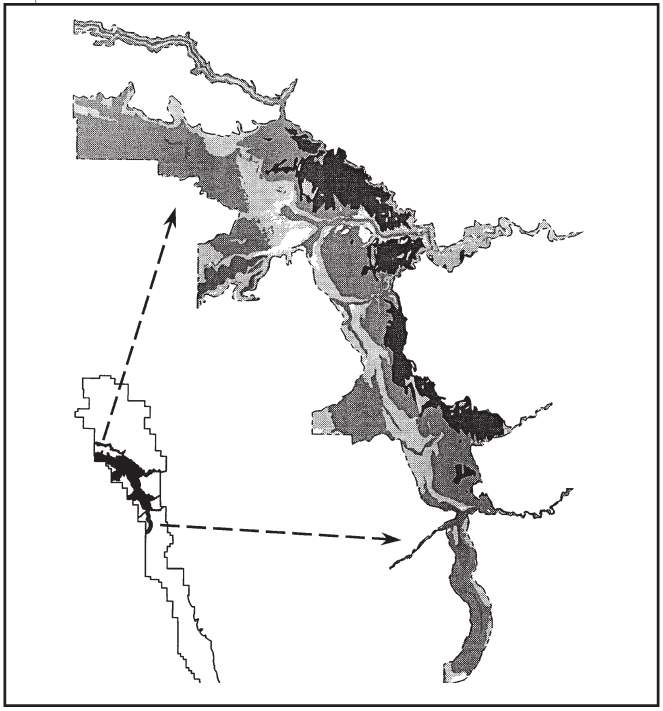

Figure 3. The study area within Capitol Reef National Park encompasses Fruita, an area that contains the majority of visitor use. Darker areas depict potential habitat for a greater number of the target species.

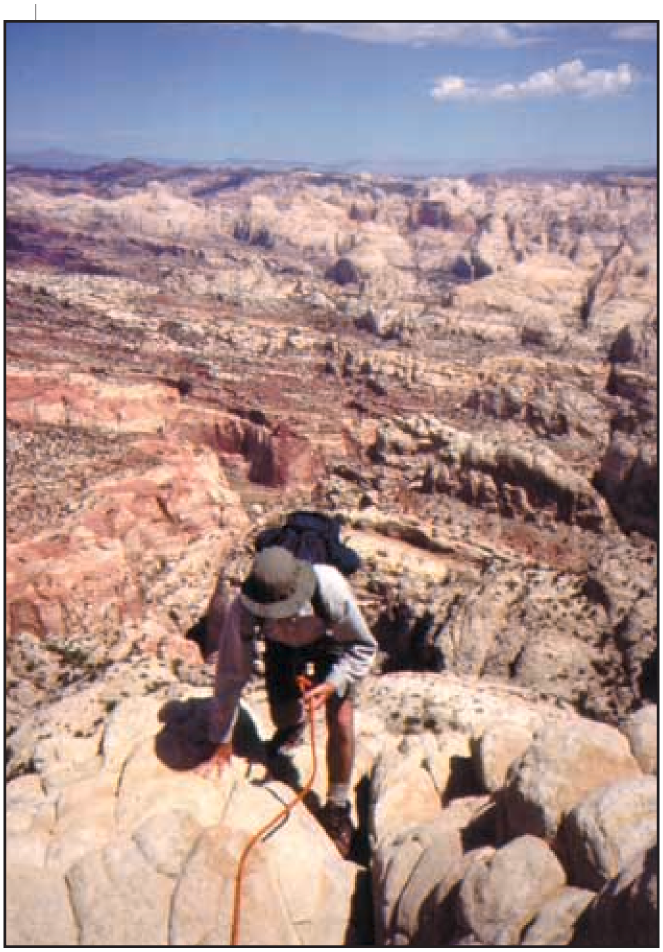

Figure 4. Field survey crews searched for Maguire's daisy, a federally endangered species, in rugged, steep terrain.

mapped so park managers would know about the potential for visitor-related impacts to these populations. All new localities were entered into the park's GIS along with a summary of data about the locality. This ensures long-term retrieval capabilities for future resource managers.

In 1998, the study progressed into the monitoring phase. Resource managers selected monitoring sites where at least 100 individuals of the target species occurred in areas of current or potential visitor impact. The interagency botanist visited each of these areas to determine whether a monitoring plot could be established without impacting the species of concern. Since all these species grow in rugged, steep terrain, some sites had to be abandoned since any monitoring efforts would have disturbed the plants, or the location was deemed too difficult to access repeatedly.

Once resource managers determined the logistical feasibility of establishing a plot at a given site, field crews set up the plots, then tagged individual plants and took their measurements. Measurements included precise location by distance along and from an established meter tape (to enable new crews to relocate individual plants during successive years), plant height, size class, number of flowering stems, and condition of plant. Since almost nothing is known about the life history of these plants, the monitoring method is designed to gather some of that information.

The crews established plots near hiking trails to measure visitor impacts and tagged plants growing within one meter of the edge of trail by burying numbered nails. A second control plot away from trail impacts was established near the "trail" plot. These control plots were located on the same slope, aspect, and soil type to reduce the number of variables that could affect monitoring results.

Survey results

Crews surveyed the twelve maintained hiking trails and four well-used routes within the Fruita area for each of the target species. They completed 87 site visit accounts, documenting information on all known and new populations of the six selected species in the Fruita study area.

Calendar year 1997 was excellent for botany work in Capitol Reef because winter and spring rainfall was above average, creating a superb year for wildflowers. A long, cool spring prolonged the bloom of several of the target species, enabling survey crews adequate time to cover thoroughly all areas of concern. This also ensured a high degree of accuracy for survey results, since plants tended to be well developed and in full bloom for a longer than average time period.

Findings by species

Barneby reed-mustard

The recovery plan for Barneby reed-mustard reports an estimate of 2,000 total plants known from two locations, one in Capitol Reef. Prior to this study, only one locality in Capitol Reef could be confirmed by botanists. This species occurs only in two geologic formations, Moenkopi and Kaibab limestone. Approximately 3,360 ha (8,400 acres) of these formations occur within the study area, however, only about one-quarter of that area is potential habitat. During this study, all potential habitat for Barneby reed-mustard within Capitol Reef was surveyed, resulting in the discovery of nine new localities and approximately 1,630 individual plants.

Maguire's daisy

The recovery plan for Maguire's daisy reports an estimate– of 5,000 individual plants known from 33 locations, representing seven separate populations. Three populations totaling 12 locations (five outside the study area) were known in Capitol Reef before the study. This species occurs only on Navajo sandstone between 1,600 and 2,500 meters elevation. There are approximately 1,920 ha (4,800 acres) of Navajo sandstone within the study area.

Surveys for Maguire's daisy focused on potential habitat adjacent to trails and routes and resulted in 20 localities being recorded (13 new ones) and approximately 1,650 individual plants being found.

Wright's fishhook cactus

The recovery plan for Wright's fishhook cactus reports an estimate of 13 locations in Emery and Wayne Counties, Utah. Only two locations were known within Capitol Reef before this study, both outside the study area. This species occurs on numerous geologic formations, and has a much wider distribution than the two previously discussed species. About 960 ha (2,400 acres) of potential habitat were estimated to be in the study area; however, very little of that acreage occurs near areas of concern. Thus, surveys focused on areas of concern and resulted in the discovery of seven new localities totaling 60 individual cacti.

Rabbit Valley gilia

Rabbit Valley gilia was a candidate for federal listing in 1997, but a conservation agreement and strategy was developed, thereby precluding the need to list it. Before the survey 13 locations for the species were known (nine in Capitol Reef) containing approximately 4,700 individual plants. This species grows only on Navajo sandstone, of which approximately 1,920 ha (4,800 acres) occurs within the study area. Surveys conducted during this study found three new occurrences containing 435 plants.

Harrison's milkvetch

This species is an NPS sensitive species. Until 1998, no extensive surveys had ever been conducted for Harrison's milkvetch. It was thought to occur at four locations in Capitol Reef, totaling about 200 individual plants. Harrison's milkvetch occurs only in Navajo sandstone. About 1,920 ha (4,800 acres) of this formation occurs in the study area, although very little of this area is actually potential habitat. Surveys confirmed the four known locations and added 14 new localities, totaling about 5,000 plants.

Pinnate spring-parsley

This species is an NPS sensitive species. Only nine localities (three in Capitol Reef), containing less than 2,000 plants were known before this study. Pinnate spring-parsley occurs in four formations: Navajo, Wingate, Kayenta, and Cutler limestone. About 3,800 ha (9,500 acres) of these formations occur within the study area; however, only about one-eighth of the area is potential habitat. This study confirmed the three known locations and added 13 new localities, totaling about 1,250 plants. However, the majority of new localities contain 20 or fewer plants. Often, one isolated plant was found in a slot canyon far from other known locations.

Monitoring plots

Crews established twelve monitoring plots for five of the target species. Resource managers determined that no monitoring plots were necessary for Wright's fishhook since the few occurrences were in areas not likely to be directly impacted by visitor activities. Monitoring plots will be maintained with annual monitoring for at least the first three years. Thereafter, the park will determine whether annual or biennial monitoring should be continued. Additional plots may be established in the future if deemed necessary.

Partnerships and products

Volunteers donated approximately 1,070 hours to this project, representing an approximate monetary worth of $10,900. Partnerships with Capitol Reef National Park for this project included seven organizations. Capitol Reef Natural History Association managed the grant budget and provided its science projects coordinator (now the interagency botanist) as staff for the project, and Zion National Park detailed one of its seasonal staff in 1997. Four universities sponsored student volunteers (Utah Valley State College, Southern Utah University, Utah State University, and Northern Michigan University), three of whom had specific internship programs through their universities. In 1997, Worthington High School in Ohio sponsored one "walkabout" high school student who assisted with GPS mapping.

The interagency botanist and interpretive staff produced two interpretive exhibits for display in the visitor center. One specifically details Canon's and NPF's role in the project, and the other describes rare plants and geology within Capitol Reef National Park. Additionally, the park installed signs at appropriate trailheads explaining the presence of rare plants along trails and encouraging visitors to stay on the trail. A leaflet educating visitors about rare plants growing in Capitol Reef National Park was developed and is being distributed in the visitor center.

Conclusions

Work accomplished by this study resulted in the discovery and documentation of several new localities for each of the target species. It also reconfirmed that each of these species is indeed very rare. Each species has its own microhabitat niche requirements that restricts it to very limited areas within the Waterpocket Fold and surrounding area. The largest increase in known localities and number of individual plants was for Harrison's milkvetch. This is because no surveys for this species had ever been conducted. Because of their extremely restricted microhabitat requirements, Barneby reed-mustard and pinnate spring-parsley were found to be the most limited species.

The timing of this grant was excellent since Capitol Reef National Park was in the process of revising its general management plan. Information gained from the 1997 portion of this project was directly applicable to the planning effort. Information gathered during this study also enabled the park to meet legal requirements of the Endangered Species Act, comply with NPS management policies, and address Government Performance and Results Act goals. Conducting surveys and establishing monitoring plots were some of the park responsibilities identified in three recovery plans and a conservation agreement. Knowledge gained about these species and their specific habitat requirements will enable park staff to ensure that these plants are protected and will assist in predicting which areas may contain additional occurrences. Future results from the monitoring plots will provide the means for park managers to make better decisions concerning visitor use and its impacts to park natural resources. PS

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Figure 1 (photo). Concern over the decline in flow of Vendome Well and the possibility that its unregulated flow might be detrimental to other artesian wells and springs in the region led the National Park Service to renovate it in 1997. A new well was drilled, supplying water to the historic fountain and doubling its flow, and the old well was plugged.

Figure 2 (map). Named in honor of the Chickasaw Indian Nation, Chickasaw National Recreation Area is located in south-central Oklahoma.

Water quantity issues at Chickasaw National Recreation Area

As historic springs diminish in flow, provisions of a water resources management plan aim at understanding the causes and mitigating the decline

By M. Nicholl[1], T. Wikle[2], T. Brown[2], J. Nord[1], and R. Parker[3]

The resource management mission of Chickasaw National Recreation Area combines facilitating public recreation with protecting historically significant artesian waters (figure 1). Located in south-central Oklahoma (figure 2), midway between Oklahoma City and Dallas, Texas, the recreation area attracts over 1.5 million visitors annually for picnicking, camping, nature study, and water-based recreational activities. The area is also historically important as a source of fresh and mineralized spring waters that has been used by generations of visitors for drinking and the purported curative powers of the mineralized waters (Brown 1998).

As a means of guiding management activities pertinent to Chickasaw's unique water resources, NPS staff initiated the development of a water resources management plan that began with an "Issues Scoping Workshop" held in December 1996. Among the critical management issues identified by the National Park Service and other stakeholders were the historical and potential future decline in flow from the area's natural springs. Quality of the spring waters was also a concern, but is beyond the scope of this article (see sidebar, page 32). Here we present an overview of the unique water quantity problems associated with maintaining springs as both natural and historical resources at Chickasaw National Recreation Area.

Historical background

Before its designation as a national recreation area in 1976, Platt National Park (now the Platt District of Chickasaw National Recreation Area—see figure 4) held the distinction of being both our nation's smallest national park and the only unit in the national park system set aside to protect resources at the request of American Indian tribes. Long before NPS management, the region containing the springs was a sacred site and hunting area for resident tribes such as the Wichita and the Caddo and nonresidents such as the Comanche. An 1855 treaty with the U.S. government placed the area containing the present-day Chickasaw National Recreation Area under the control of the Chickasaw Nation.

In the late 1880s, development pressures rising from the popularity of the springs prompted the Chickasaw to cede the area to the U.S. government for protection. In 1902, Congress created the Sulphur Springs Reservation; four years later, it was renamed Platt National Park in honor of Connecticut Congressman Orville Hitchcock Platt. Included within its boundaries were 33 springs used by both local residents and visitors.

During the 1930s, the Civilian Conservation Corps constructed a number of improvements within the park, including pavilions, bridges, and weirs (figure 3). While the springs remained popular, visitor activities in the area were beginning to shift towards recreational pursuits. Recognizing the change in visitor interests and seeing an opportunity to better serve the demand for water-based recreation, the Congress redesignated Platt National Park as a national recreation area in 1976. With its change in status, the new Chickasaw National Recreation Area was enlarged to include the nearby Lake of the Arbuckles. In addition to providing recreational boating, swimming, and fishing opportunities, the lake serves as a flood control reservoir and water supply for surrounding communities. The recreation area was enlarged again in 1983 to its present size of 4,050 hectares (10,000 acres) through the acquisition of Veterans Lake (27 hectares; 67 acres) from the city of Sulphur (figure 4).

Groundwater at Chickasaw

A significant problem facing resource managers at Chickasaw National Recreation Area is that the underlying rock formations have yet to be studied in sufficient detail to fully understand the subsurface flow system that feeds the natural springs. South-central Oklahoma has a very complex geologic history that includes the building and subsequent erosion of the Arbuckle Mountains, located to the south of the recreation area. As a result, rock for-

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Figure 3. During the 1930s, the Civilian Conservation Corps constructed several improvements at what is today Chickasaw National Recreation Area. These included the pavilion, shown here, at Pavilion Spring.

mations in the vicinity of Chickasaw also show a high degree of complexity, exhibiting numerous folds, faults, and abrupt changes in rock type, much of which has not been studied.

The majority of the near-surface rocks in the recreation area belong to a geologic unit known as the Vanoss Formation. This well-cemented conglomerate is extremely dense and mostly impervious to the flow of water, except where it is fractured. Rock units that are impervious to water are known as confining layers, because they "confine" the flow of water to the underlying aquifer. Below the Vanoss Formation lie the Arbuckle (freshwater) and Simpson (mineralized) aquifers, which permit water to pass through fractures and pore spaces. Mountain building and erosional processes have left portions of the Arbuckle and Simpson aquifers exposed near the earth's surface in a region that is higher in elevation, and generally to the east of the recreation area. Rainwater percolating into the aquifers flows toward the recreation area beneath the confining Vanoss Formation.

Just like water flowing through a pipe, water in confined aquifers is under pressure. In the Arbuckle and Simpson aquifers, water pressure is sufficiently high to raise water to the surface at breaks in the confining layer (Vanoss Formation). Artesian springs form at natural breaks in the confining layer, and wells drilled into the aquifer will flow freely without the aid of pumps (artesian wells). At any given time, the amount of water that flows from artesian wells and springs is a direct function of pressure within the aquifer. If pressure goes up, flow will increase, and vice-versa. An illustrative example of a typical artesian aquifer is shown in figure 5 (page 32), although insufficient information exists to produce a diagram that accurately depicts conditions at Chickasaw National Recreation Area today.

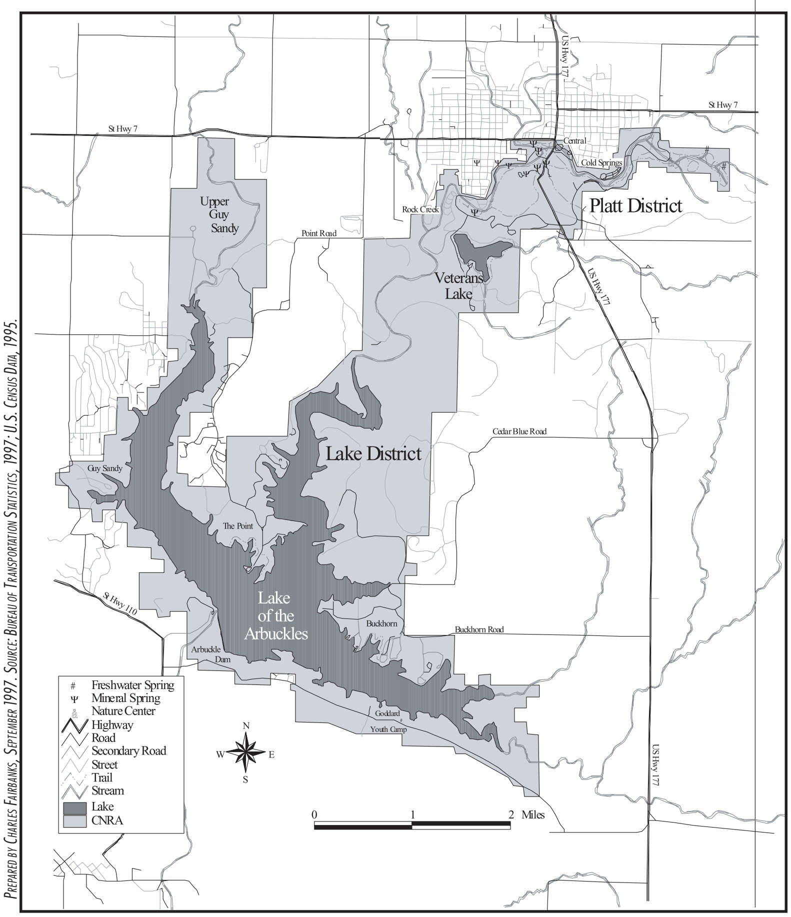
As water flows through an aquifer, it dissolves minerals in the rock. The amount of dissolution is a function of rock type and the amount of time that the water remains in the aquifer. In rocks of normal to low solubility, water that moves slowly becomes mineralized, while water that moves more quickly remains fresh. Each spring at the recreation area is connected to the underlying aquifer in its own way; therefore, the chemical makeup of the mineralized waters differ from spring to spring. Chemical species found in the mineralized springs at Chickasaw include sodium, calcium, magnesium, chloride, bicarbonate, and sulfate (Hanson and Cates 1994). Chemical makeup of the spring water is also dependent on that of the rainwater that initially percolates into the aquifer in the upland areas. Therefore, land uses in these upland areas may potentially impact water quality within the aquifer, and hence the springs (see sidebar, page 32).

Water quantity issues

Although a field survey conducted in 1906 identified 33 active springs within what is now the Platt District of Chickasaw National Recreation Area, a more recent survey in 1987 identified only 21 springs, some of which were barely noticeable due to low flow (Taylor 1988). Among springs that have ceased to flow are two of the most popular, Bromide and Medicine Springs. Estimates in 1939 suggested that total spring discharge had declined approximately 80% from a 1906 estimate of 14,160 liters per minute (3,741 g/min). Several springs had ceased to flow entirely by that time (Hanson and Cates 1994).

The observed decline in spring flow has become one of the most troubling questions facing resource managers at the recreation area. Spring flow is determined by pressure within the Arbuckle and Simpson aquifers, as discussed, which in turn is controlled by the balance between inflow (recharge) and outflow (discharge). The source for recharge is precipitation, which has remained relatively constant over the past 90 years. However, land use has changed dramatically within this same time frame, possibly influencing the fraction of precipitation that percolates through the soil to recharge the aquifers. In addition, a significant number of artesian wells have tapped the aquifer system since the area was first developed. The extent to which withdrawals from these wells may have reduced pressure within the aquifer system is currently unknown.

The water quantity issues illuminated during the 1996 workshop resulted in publication of the Water Resources Manage-



Prepared by Charles Fairbanks, September 1997. Source: Bureau of Transportation Statistics, 1997; U.S. Census Data, 1995.

Figure 4. Detailed map of Chickasaw National Recreation Area.

"Chickasaw" continued on page 32

"Chickasaw" continued from page 31

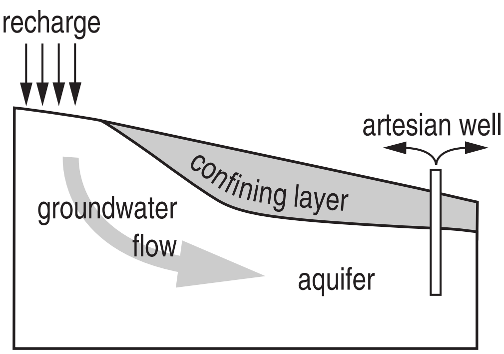


Figure 5. Generic geologic cross-section showing confined aquifer, spring, and artesian well.

ment Plan (Wikle et al. 1998) for the recreation area. Through resource management project statements, the plan details strategies for, among many others, investigating the dynamics of the aquifer flow system, restoring flow to Bromide Spring, and controlling the flow of Vendome Well, the first project to be completed.

Regulation of Vendome Well

The best known artesian well in the region is Vendome Well (see fig. 1, page 30), located on Highway 7 just south of Sulphur. Drilled outside of park boundaries in 1922 and purchased by the National Park Service in 1980, Vendome remains a popular tourist attraction and cultural landmark for Sulphur residents.

Discharge rates for Vendome have declined from approximately 9,500 liters per minute (~2,500 g/min) in 1922 to around 1,900 liters per minute (~500 g/min) in 1992 (Hanson and Cates 1994). Factors believed to be responsible for the declining flow of Vendome include a general reduction in aquifer pressure and deterioration of the well casing. Park staff suspect, too, that uncontrolled discharge from the well and leakage from the subsurface well casing may have contributed to the decline in discharge rates of mineralized springs elsewhere in the recreation area.

Because of the interest in preserving the discharge of all artesian wells and springs in the region, the National Park Service has recognized the importance of regulating the discharge of Vendome Well without compromising the cultural or historical integrity of the site. To that end, renovation of Vendome Well began in October 1997.

A new well was drilled to a depth of approximately 229 meters (750 feet) at a location approximately 9 meters (30 feet) to the west and south of the original well (Christensen 1998). The new well produced water at a rate of around 3,800 liters per minute (~1,000 g/min); taste and smell of the water was similar to that issuing from the original fountain. After ascertaining the suitability of the new well, the original was plugged. In 1998, flow was routed from the new well into the existing fountain. Valves installed in the new well will allow flow to be controlled in accordance with management goals.

Long-term monitoring

In order to provide better information for decision-making, the water resources management plan recommends that the National Park Service implement a water quantity monitoring program that includes installation of flow gauges at each of the recreation area's springs. Although the U.S. Geological Survey maintains recording gauges to measure stream flow, the location of their equipment does not allow data collection for individual springs. Such data will be useful in determining a baseline flow for each spring, establishing trends relative to precipitation and other climatic factors, and evaluating potential mitigation measures that can be initiated by the National Park Service and surrounding water users. Information concerning withdrawal rates corresponding to artesian wells will also be needed in order to create a comprehensive water budget for the region. PS

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Water quality issues

According to a 1997 report by the National Park Service, surface waters within Chickasaw National Recreation Area and the surrounding region have been significantly impacted by human activities. The report noted that potential sources of contaminants include municipal and industrial wastewater discharges; storm water runoff; agricultural, livestock, and fish hatchery operations; oil and gas development and residential development; quarrying operations; recreational use; and atmospheric deposition.

Screening tests performed on surface waters in the Chickasaw NRA region since the 1950s suggest that fecal coliform, dissolved oxygen, copper, and chloride are the parameters that fail to meet EPA drinking water quality standards most often (Wikle et al. 1998). Additionally, Hillside Spring has had a long history of intermittent bacterial contamination from fecal coliform and fecal streptococci (Wikle et al. 1998).

As with the water quantity concerns, water quality issues are being addressed through several project statements outlined in the Chickasaw Water Resources Management Plan.

Profile of the USGS Columbia Environmental Research Center

By Marcia Kelly Nelson

Editor's Note: This is the third profile to appear in Park Science *of a science and technology center operated by the USGS Biological Resources Division (see also* **18(1)***:13-14 and* **15(3)***:12-13). The nationwide network of 16 centers (a 17th is soon to be added) was described in* **15(2)***:24-26 of this publication and is detailed on-line at http://biology.usgs.gov/pub_aff/centers.html. Park managers with research and technical assistance needs related to environmental contamination and its effects on habitat will find useful expertise and research activities described below.*

Figure 1. Known as a semipermeable membrane device or SPMD, this sampling tool was invented at the Columbia Environmental Research Center and is deployed to collect in situ contaminants. The device is a "virtual fish," mimicking the parts of animals that cause contaminants to bioconcentrate. It is a long, flat, plastic tube that contains oil that allows contaminants to pass through, like membranes of animal cells. The oil is similar to a highly purified fish fat in which most contaminants readily dissolve and become concentrated, as if in the fat of a fish.

Clean water resources and habitat quality are essential for the health of all living organisms, a fundamental concept in the mission of the Columbia Environmental Research Center (CERC). The center provides scientific information and data for the U.S. Geological Survey and its clients, including the National Park Service, needed to address national and international environmental contaminant issues and to assess effects of habitat alterations on aquatic and terrestrial ecosystems. The center has a unique capability for conducting both focused and large-scale multidisciplinary research that includes, but is not limited to, large-river floodplains, coastal habitats, wetlands, and lakes. Emphasis is on projects that integrate scientific disciplines to address complex environmental issues on large geographical scales. Scientists at CERC form partnerships with national, state and local agencies, nongovernmental organizations, and universities to enhance scientific information needed for management of the nation's resources.

CERC is one of 16 science centers in the U.S. Geological Survey's Biological Resources Division. Historically, the center was established in 1959 at the Denver Wildlife Research Center of the U.S. Fish and Wildlife Service and was called the Fish Pesticide Research Laboratory (FPRL). In 1966, the University of Missouri deeded 33 acres to the Fish and Wildlife Service and the FPRL moved to its present location. The partnership initiated between the university and the laboratory in 1966 remains strong today through a number of cooperative research programs. The center was incorporated into the U.S. Geological Survey Biological Resources Division in 1996. The name of the laboratory was changed to CERC in 1998. In addition to the main facility in Columbia, Missouri, CERC administers seven field research stations located across the nation.

Center organization

About 150 federal and contract employees, with an extensive range of scientific and technical expertise, staff CERC. Research areas and services cover broad aspects of environmental toxicology and chemistry, ecology, ecogeography, large-river ecology, and information and technology transfer. The center's science program is organized into seven branches: Toxicology, Ecology, Ecogeography, Environmental Chemistry, Biochemistry and Physiology, Field Station Research, and Information Transfer.

Environmental toxicology, is the functional responsibility of the Toxicology Branch. The branch scientists develop, apply, and validate methods for assessing the effects of contaminants and other environmental stressors on aquatic organisms. Research focuses on bioaccumulation and toxicity of contaminants from water, sediment, and food; the physical, chemical, and biological factors affecting these processes; and relationships between laboratory responses and characteristics of contaminated aquatic ecosystems. Disciplines include invertebrate and vertebrate toxicology, limnology and benthic ecology, and culture of aquatic organisms.

Research of the Ecology Branch focuses on understanding the effects of habitat alteration caused by environmental contamination, physical destruction, eutrophication, exotic species, and climate change on aquatic systems. The ecological investigations are integrated with other biological, chemical, and physical science programs at CERC to provide a comprehensive understanding of habitat alteration on aquatic populations and communities. The Ecology Branch has laboratory, field, and mobile facilities to conduct ecological assessments under controlled and natural environments. The branch is extensively involved in cooperative research with other federal, state, and private institutions to meet the research needs of client agencies, to develop standardized methods and guidelines, and to

Two CERC field research stations are closely allied with national park research needs, and are located at NPS facilities

"CERC" continued on page 34

"CERC" continued from page 33

contribute to the basic scientific knowledge concerning human impacts to natural systems.

The Ecogeography Branch investigates the spatial and quantitative relationships among the biotic and abiotic components of the environment. The branch has expertise in landscape analysis, landscape ecology, fisheries biology, geographic information systems (GIS) analysis, collection of geographic positioning systems (GPS) and bathymetric data, hydraulic modeling, statistical consultation, geomorphology and surficial processes, environmental monitoring and risk assessment. Ecogeography scientists are responsible for providing information and technical support for the development and use of digital databases for natural resource planning and management, and for conducting research at an ecosystem scale. The USGS River Studies Station (RSS), located at the center, is included in the research program of the Ecogeography Branch. The station's mission is to increase the understanding of how management and restoration activities function on large-river systems through a comprehensive and integrated science approach. River studies research emphasizes how management changes in the physical and chemical condition of rivers affect habitat and ecological conditions. Areas of expertise RSS include expertise in fisheries biology, aquatic and terrestrial ecology, hydrology, hydraulics, floodplain configuration and evolution, remote sensing, and GIS.

The Environmental Chemistry Branch is critical to the integrated approach of chemical discovery and biological cause and effect (figure 1, page 33), the basis of environmental contaminant research in the USGS. Environmental chemistry research encompasses all areas relating to environmental pollution, including analytical methods development, fate of environmental contaminants, development of techniques for defining bioavailability, bioconcentration potential, and determining toxicological significance of exposure to contaminant residues. The branch conducts aquatic, terrestrial, and atmospheric ecosystem research and collaborative projects with other CERC scientists as an integral part of the center's anticipatory research approach. The branch provides environmental science information to the public, other Department of the Interior agencies, and the scientific community through presentations and scientific publications. The branch's scientists are nationally and internationally known for their research and are often consulted by other researchers in environmental science.

The Biochemistry and Physiology Branch conducts basic and applied research at the cellular, organ, and organismal levels in fish and wildlife. Emphasis is on the sublethal effects of chemicals that lead to behavioral, developmental, and population changes that may ultimately influence ecosystem health. Scientists in the branch identify biochemical and physiological indicators of individual toxicant stressors in addition to overall physiological effects and toxicity of complex chemical mixtures. Research focus includes reproductive, developmental, and neurotoxic effects of stressors. The branch develops and uses analytical techniques such as microscale assay, cell bioassay, and immunoassay, to quantify exposure and estimate toxicity in both lab and field studies. In addition, branch scientists study the mechanism(s) of action of contaminants to develop and validate sublethal indicators of chemical stress.

The Field Station Research Branch specializes in ecological and toxicological research that is relevant to natural resource issues in the Texas/Gulf Coast, intermountain West, and Great Lakes/Great Plains regions of the United States. Research stations are located in Corpus Christi, College Station, and Padre Island, Texas; Jackson, Wyoming; Yankton, South Dakota; and International Falls, Minnesota. Scientific expertise at the research stations includes marine ecotoxicology; sediment toxicology; waterfowl and avian ecology; wildlife ecology; ecotoxicology of mammals, reptiles, and amphibians; sea turtle ecology; assessment of acid or metals effects in native western fishes; natural resource damage assessments; agricultural irrigation drainwater assessment; and aquatic community evaluations of endangered, native, and invasive fish species. Capabilities include both laboratory and on-site field assessments. Research activities are conducted in collaboration with a wide variety of federal, state, university, international, and nongovernmental cooperators.

The Information Technology Branch is dedicated to providing traditional and contemporary data distribution and management systems to retrieve the most current scientific information. An emphasis is placed on the discovery, access, and full use of information sources available through the Internet and World Wide Web. The center plays an active role in developing the National Biological Information Infrastructure, a network of distributed databases and information sources for biological information. The branch organizes the analyzed and reported data collected in research investigations and ensures rapid dissemination of research metadata into national databases. Emphasis is placed on training and keeping research staff abreast of rapid changes in computer technology, coupled with increasing emphasis on interdisciplinary science, information exchange, and multimedia presentations, particularly over the World Wide Web. The center's homepage can be viewed at http://www.cerc.usgs.gov/.

Field stations located at national parks

Two CERC field research stations are closely allied with national park research needs, and are located at NPS facilities. Sea turtle ecologist, Donna Shaver-Miller, conducts sea turtle research along the Texas coast at Padre Island National Seashore (see story on page 16, this issue), and fisheries biologist, Larry Kallemeyn, conducts fisheries research on native and exotic fishes in lakes of Isle Royale National Park, Michigan, and Voyageurs National Park, Minnesota.

Obtaining assistance

The Columbia Environmental Research Center offers technical assistance in all of its areas of expertise. If you have an environmental problem you would like to discuss or need any information related to our research efforts, we want to hear from you. If you have a national park research project in which CERC can offer some expertise, do not hesitate to contact us. For more information on contacts or on the areas of expertise at CERC, consult table 1 or visit the center's website. PS

Marcia Kelly Nelson is the Outreach Coordinator for the Columbia Environmental Research Center. In addition to handling many aspects of external affairs for CERC, which includes intergovernmental affairs, she promotes science education and awareness of the center's role and activities. She can be reached at CERC; USGS Biological Resources Division; 4200 New Haven Rd.; Columbia, MO 65201; 573-876-1875; marcia_nelson@usgs.gov; http://www.cerc.usgs.gov/.

Table 1. USGS Columbia Environmental Research Center contacts

Branch	Research Areas or Services	Ongoing/Recent NPS-Related Projects
Center Director Wilbur "Bill" Mauck 573-876-1900 bill_mauck@usgs.gov	Research and development planning and coordination.	
Toxicology Christopher G. Ingersoll, Branch Chief 573-876-1819 chris_ingersoll@usgs.gov	Assessing biological effects of contaminants and other environmental stressors on aquatic organisms.	
Ecology Edward E. Little, Branch Chief 573-876-1817 edward_little@usgs.gov	Understanding effects of habitat alteration caused by environmental contamination, physical destruction, eutrophication, exotic species, and climate change on aquatic systems.	Evaluation of ultraviolet radiation as a factor in amphibian decline in montane habitats in Glacier, Rocky Mountain, Sequoia, and Olympic National Parks (Ed Little).
Ecogeography Pamela S. Haverland, Branch Chief 573-876-1841 pamela_haverland@usgs.gov	Investigations of spatial and quantitative relationships among the biotic and abiotic components of the environment.	Evaluating the links between tributary land use and aquatic habitat quality on the Buffalo, Jacks Fork, and Current Rivers within park boundaries in the Buffalo National River and Ozark National Scenic Riverways (Robb Jacobson).
Environmental Chemistry Jim D. Petty, Branch Chief 573-876-1824 jim_petty@usgs.gov	Encompasses all areas relating to environmental pollution, including contaminant fate, development of analytical methods, techniques for defining bioavailability, bioconcentration potential, and determination of toxicological significance of exposure to contaminants.	
Biochemistry and Physiology Donald E. Tillitt, Branch Chief 573-876-1886 donald_tillitt@usgs.gov	Conducts research on the sublethal effects of chemicals that lead to behavioral, developmental, and population level effects that ultimately influence ecosystem health.	
Field Station Research Laverne Cleveland, Branch Chief 573-876-1874 laverne_cleveland@usgs.gov	Specializes in ecological toxicological research relevant to natural resource issues in the Texas/Gulf Coast, Intermountain West, and Great Lakes/Great Plains regions of the United States.	Sea turtle ecology/recovery at Padre Island NS (Donna Shaver-Miller); aquatic community evaluations of endangered, native, and invasive species at Isle Royale and Voyageurs NPs (Larry Kallemeyn); effects of geothermal additions on the biology and distribution of trout in the Firehole River of Yellowstone NP (Dan Woodward); water quality investigations in Garnet Canyon and lower Cascade Canyon, and winter movements and habitat use of Snake River cutthroat trout in Grand Teton NP (Dan Woodward), contaminant investigations in the food chain of peregrine falcons in Big Bend NP and other areas of the Chihuahuan Desert (Miguel Mora).
Information Technology Ted R. Schwartz, Branch Chief 573-876-1832 ted_schwartz@usgs.gov	Information management, library, technical editing, and computer support and applications.	

Developing a plan for long-term ecological monitoring: A focused workshop approach

By Bruce Freet and Kent Turner

Every day, resource managers throughout the national park system endeavor to fulfill the NPS mandate to preserve park resources. Yet, how do we measure and assess our success in meeting this charge? Resource conditions change over time due to the normal variation in the biophysical environment, but are the resources in better or worse condition during our tenure as stewards? Was the change induced by human activities or by "natural" processes?

Long-term ecological monitoring (LTEM) is attempting to answer such questions. Embraced by the National Park Service under its Inventory and Monitoring Program, LTEM is a fundamental aspect of park resource management as it ultimately helps us understand resource conditions. Parks designated as LTEM prototype parks have long recognized the importance of developing conceptual plans as an important first step in determining what to monitor. Since we cannot afford the time and money to monitor everything, we need to identify the key indicators of change or "vital signs" that we should concentrate on and which attributes to measure.

Recently, the LTEM concept has been combined with the Pacific West Region's initiative to identify and monitor natural and cultural resource vital signs. Vital signs are reliable, early warning signals by which we can measure and detect changes that will impair the structure and functions of ecosystems. During 1998, North Cascades National Park Service Complex (Washington) and Lake Mead National Recreation Area (Nevada and Arizona) conducted workshops with the goal of determining methods for taking vital signs of resource condition and detecting change over time. This effort can also assist us in promoting a teamwork approach to resource stewardship.

The North Cascades approach

North Cascades NPS Complex (includes North Cascades National Park and Lake Chelan and Ross Lake National Recreation Areas) began the LTEM conceptual plan as a logical step-down chart process, beginning with the NPS mandate. Based on the mandate and a guiding statement from the park's enabling legislation "to preserve … certain majestic mountain scenery, snow fields, glaciers, alpine meadows, and other unique natural features," we focused primarily on the relationship of monitoring (figure 1) to broad management responsibilities to conserve and protect the scenery, natural resources, and public use and enjoyment. A draft outline of the conceptual plan was completed before the workshop to provide the vision and foundation for our deliberations.

To ensure that our LTEM workshop in March 1998 was as productive as possible, we formulated clear, concise objectives and desired products before the gathering. Reed Glesne, an aquatic ecologist on our staff, and Dave Peterson, an ecologist with the USGS-BRD Forest and Rangeland Ecosystem Science Center, developed four goals for our conceptual step-down model and plan:

- Enhance basic resource knowledge (baseline resource inventories)
- Determine status and trends in resource condition (change over time)
- Utilize multiple indicators and metrics for early detection
- Maximize the utility of existing monitoring protocols and results

The specific workshop objectives were:

- Workshop participants will provide relevant information and scientific literature
- The North Cascades NPS Complex staff will review resource inventories and issues
- Scientists and resource management staff will jointly select indicators (*what*) for the early detection of change
- Workshop participants will justify *why* indicators were selected and prioritize them, quantify appropriate spatial and temporal scales (*where* and *when*), and (3) recommend strategies and metrics for implementation (*how*).

The workshop outcomes and products were used to develop the LTEM conceptual plan with prioritized resource management plan project statements, update the park's LTEM bibliography, and document workshop recommendations. This focused, product-oriented approach allowed us to develop a substantial amount of written documentation over a short period of time, while directly integrating the LTEM plan with the park's resource management plan.

Although most components of the LTEM program emphasize natural resources, we also included human resources and cultural resources because of their direct link to natural resources. Inventory, monitoring, assessment of resource conditions, and refinement of management strategies are adaptive management tools that the entire park staff–including human and cultural resource specialists–should be using. Federal monitoring programs are often not viable, because political and managerial priorities vary over time and divert funding from critical monitoring activities. If we incorporate LTEM programs with other park operations, we hope that long-term monitoring can become institutionalized and survive, thereby producing useful time series of data. For example, the trail maintenance crew in North Cascades has a strong environmental ethic but no monitoring responsibilities. They could monitor *limits of acceptable change* for designated trails and backcountry campsites (e.g., width of trails, number of social trails, soil bulk density). We anticipate that our entire Resource Management Division will have responsibilities in the LTEM program, rather than having a separate LTEM workforce. In fact, everyone in the division *wants* to be involved, which ensures ownership of the program by park staff.

The direct interaction of park staff and scientists before and during the workshop helped to focus workshop activities on a predetermined model for the LTEM plan and minimized discussions that were tangential to objectives for developing the plan. To facilitate an efficient workshop, we spent considerable time compiling information for workshop participants, including summaries of park resource issues, ecological processes potentially affected by environmental stress, potential monitoring parameters, criteria for monitoring components, and criteria for meeting monitoring goals. A conceptual model for LTEM at the watershed scale was developed and included in the workshop packet. Since then, Dave Peterson and Paige Eagle have helped us develop and publish on-line (www.nps.gov/noca/Ltem/Index.htm) the entire LTEM conceptual plan, including step-down charts, templates, and descriptions of natural and cultural resources.

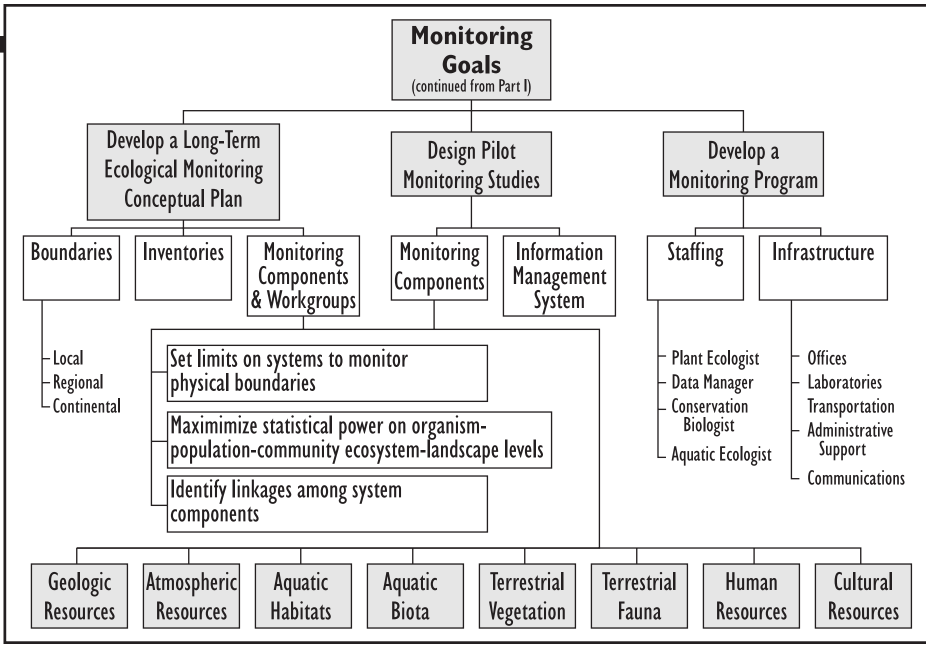

Figure 1. Development of an LTEM conceptual plan for the North Cascades complex grew out of the NPS mandate and the park's originating legislation (part I—not shown). The step-down process led to evolving criteria for meeting monitoring goals, shown in the chart (part II), and to identification of eight principal resource components requiring long-term ecological monitoring.

Resource specialists on the park staff led off the 2½–day workshop with brief overviews on specific park resources, including summaries of existing inventories and data. Workshop participants were divided into eight work groups, each of which addressed a different topic: aquatic biota, aquatic habitats, atmospheric resources, cultural resources, geologic resources, human resources, terrestrial biota, and terrestrial habitats (fig. 2, page 38). We employed facilitators–scientists Gary Davis (Channel Islands National Park) and Dave Peterson–who provided oversight of workshop proceedings, kept discussions on track, and ensured consistent output among work groups. They also encouraged discussions between work groups to ensure that appropriate resource linkages were recorded. Each work group had a subject-matter specialist as its team leader and a park staff member as its recorder. This organization gave specific individuals responsibility for group dynamics, focus, products, and documentation.

The work groups efficiently completed the component identification template designed by Lake Mead staff and developed them into draft conceptual models. Each template addressed a single monitoring component and detailed related information: (1) the monitoring/research questions to be addressed; (2) stressors on the resource and any related factors; (3) what to inventory; (4) what to monitor; (5) where to monitor; (6) justification for monitoring the resource and other information; and (7) potential partners. These draft materials were subsequently sent to every workshop participant for review and revision, and the resulting draft was sent to subject-matter experts for further review. We also placed the draft LTEM plan on a website to facilitate wider review. The entire process, from planning through final product required approximately a year. We may establish an LTEM scientific review committee to help us to stay focused on the vital signs, improve data management and analysis, assure connection to management issues, and promote integration between various monitoring components. Our resource management staff should work closely with any committee to assess how well the LTEM program is meeting its objectives.

The Lake Mead approach

To guide the Lake Mead LTEM program, we adopted the goal of maintaining vital signs of ecosystem health within their "normal range of variation." The goals of our vital signs workshop in January 1998 were:

- Provide a peer review of the current resource management program
- Ensure that staff are knowledgeable of all functions and processes necessary to maintain ecosystem integrity
- Provide direction for a long-term monitoring program for the assessment of resource conditions and ecosystem health

Similar to the North Cascades approach, we spent considerable time planning for the workshop. The planning team–Gary Davis; USGS-BRD scientists Bill Halvorson, Kathryn Thomas, and Peter Stine; and Dave Van Cleeve (Superintendent, Colorado Desert District, California State Parks)–met with us to define goals, objectives, and products for the workshop and LTEM program.

Approximately 50 scientists and resource managers from a variety of disciplines around the Mojave Desert attended the workshop. Before the meeting, we provided each participant with an informational package that included a narrative on the workshop process; park resource information; the Lake Mead NRA conceptual ecological model; a model of the recreation area's resource management program; a sample component identification template; examples of vital signs and criteria for their selection; and the final templates to be completed during the workshop.

Resource management staff described the ecosystem model, outlining ecosystem components, drivers (e.g., climate, fire, geologic events), and stressors. We also presented a model of the resource management program at the recreation area, based on a previously developed step-down chart. Invited scientists gave presentations on selected features of the ecology of the Mojave Desert and limnology of Lake Mead.

We then divided into work groups that focused on air quality; groundwater hydrology; the lake ecosystem; soils and related microbiota; vegetation; and wildlife. The groups were asked to identify (1) significant ecosystem components not addressed in the park's conceptual model; (2) anthropogenic stressors affecting the ecosystem; (3) monitoring questions related to the stressors; and (4) vital signs related to the stressors. Next we prepared the standard template, documenting over 80 vital signs during this process.

The meeting summary was provided to each participant for review. Following the first comment period, the eight participating scientists provided a peer review of the results. We met with the peer review team in May 1998 to synthesize and integrate results, and developed priorities and strategies for implementing the long-term, vital signs monitoring plan. With the help of the review team, we established a framework for vital signs monitoring, goals for the monitoring program, an initial list of 15 high-priority vital signs, and strategies for implementation.

This progression led us to establish three major goals for long-term, vital signs monitoring:

"LTEM" continued on page 38

"LTEM" continued from page 37

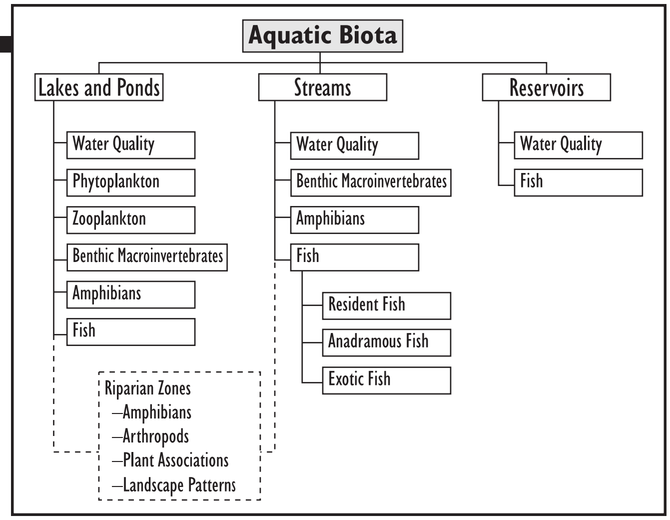

Figure 2. The North Cascades work groups developed a complete set of conceptual models for monitoring various park resources, including aquatic biota. The entire set of models is posted on the North Cascades website (www.nps.gov/noca/Ltem/Index.htm) along with the component identification templates. The templates identify what to monitor for each resource. For example, the key indicators or vital signs for phytoplankton are abundance, species composition, and chlorophyll.

- Preserve underlying ecosystem integrity (ecosystem health)
- Understand the ecosystem, based on knowledge of resources
- Practice management performance monitoring (expected vs. actual results, refined through adaptive management). This goal includes compliance monitoring (mandated or special interest species), and monitoring to maintain the quality of visitor experiences (e.g., dark night sky, water clarity)

To implement long-term monitoring, we outlined a four-tier framework where tier 1 addresses those functions or processes related to maintaining ecosystem productivity (e.g., soil fertility, hydrological functions). Tier 2 applies to the maintenance of ecosystem health (e.g., plant community structure), and tier 3 relates to maintenance of biodiversity (species distribution and abundance). The quality of the visitor experience, and visitor interactions with the resource are outlined in tier 4.

Implementation strategies blended various approaches to monitoring with opportunities for interdisciplinary monitoring. They include monitoring a transect of intensive plots (leading to greater understanding and indices for predictive modeling) and extensive plots (greater spatial coverage); stratification of the park by soils and vegetation maps; change-detection monitoring (rapid assessment); and employing variable-return intervals. The use of interdisciplinary monitoring leads to the integration of vital sign components, providing more detailed understanding and greater efficiency. For example, we are considering establishing intensive plots that would combine monitoring of soil properties, nitrogen deposition, alien flora, invertebrates, and small mammals.

We are working with USGS-BRD staff to develop monitoring protocols for soils monitoring. We are also seeking funding to develop an interdisciplinary monitoring protocol (including hydrology, vegetation, birds, invertebrates, and amphibians) and a lake ecosystem/limnology protocol as our highest priorities.

Lessons and recommendations

North Cascades NPS Complex and Lake Mead NRA agree on the general approach to developing a long-term ecological monitoring plan, despite differences in biogeographic setting and in monitoring objectives. Both parks used a similar approach for planning, conducting, and summarizing the results of workshops. Each park ended up with a detailed, scientifically based plan that will guide future monitoring efforts.

We found that a 2½–day, focused workshop is a time-efficient and cost-effective means of developing a long-term monitoring plan. However, workshops are successful only if they are highly structured and well organized. We attribute the success of our workshops and subsequent monitoring plans to:

- extensive planning before the workshop, in which existing inventories, data, and issues were compiled;
- development of conceptual models to represent various park ecosystem functions and potential monitoring strategies;
- assemblage of all resource baseline inventories and selected presentations;
- clear statements of objectives and expected products for the workshop and monitoring plan, as well as a statement of management objectives and priorities;
- use of facilitators and focused work groups;
- use of a component identification template, which provided a consistent format for recording information and ideas;
- thinking in terms of monitoring suites of species, attributes, or their habitats;
- prompt synthesis and integration of workshop results, followed by additional scientific review;
- long-term commitment by park staff and a scientific-review team.

The importance of long-term commitment cannot be overstated. Monitoring responsibilities must be formally integrated with the resource management plan and operationally integrated with day-to-day resource management activities. Personnel and priorities may change over time, but park staff must have full participation in the development and implementation of the monitoring plan and data collection.

North Cascades NPS Complex included cultural resources and human resources work groups within its LTEM program, while Lake Mead NRA did not. Although the concept of vital signs monitoring is better suited to natural resources, we need to consider how assessments of cultural and natural resources can be integrated in a common framework. Parks that are planning long-term monitoring programs need to develop means to consider both cultural and natural resources in order to meet NPS Organic Act, General Authorities Act, National Historic Preservation Act, and Government Performance and Results Act requirements.

With the threat of increased environmental stress in many of our parks and protected areas, a long-term monitoring plan is one of the cornerstones of a sound resource management program. While there are many ways to develop a monitoring plan, our successful application of a similar workshop-based strategy suggests that this approach may lead to a favorable outcome, the development of a plan, and ultimately implementation of a monitoring program. Since our workshops in 1998, an additional six parks in the Pacific West Region have held similar vital signs workshops, with five more planned in fiscal year 2000. We offer our approach as a potential model for application in other parks that are interested in developing monitoring plans. We solicit your comments on how this approach can be improved. PS

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Protected areas, science, & the 21st century

By John J. Reynolds and Christine M. Schonewald, Ph.D.

Editor's Note: *The following is an edited excerpt from a presentation by John Reynolds, Pacific West Regional Director, given at the Third International Conference on Science and the Management of Protected Areas (SAMPA III) in Calgary, Alberta, on 16 May 1997. Coauthored by Christine Schonewald, Research Scientist with the USGS Biological Resources Division, these thoughts, as the title suggests, are relevant at the millennium.*

Science will and must occupy a crucial center in the management of protected areas in the future. Our paper does not focus on the biological or physical sciences. It would have, even a decade ago, maybe even five years ago. Rather, it focuses on the interests of people and their values, and the need to bond protected areas to the societies within which they exist. This turns the early 20th century idea of "boundary" inside out–no longer is a boundary a line of certain demarcation (i.e., if a resource lies inside the boundary, it is protected and we will do the protecting). No, today a boundary must be seen as something like a "diffusion filter." But what a change! To a traditionalist, this sounds weak, puny, almost like giving up.… But our societies interact with our protected areas in ways Frederick Law Olmsted might not be surprised about, but many protected area managers would be. What a change!

There is a paper at this conference that's different than all the rest. There's a brave soul out there who's on to something and has guts enough to face his peers with it. The title is "A fuzzy framework for managing landscape modeling concepts." Fuzzy logic in protected area management? What's next?

Well *that's* next. Listen to some of his abstract: "Imprecision, nonspecificity, vagueness, and inconsistency are considered undesirable features when trying to define policies or implementations," and "much of the logic used in human reasoning is a logic with fuzzy truths and fuzzy rules of inference."

Does that ring true for managing protected areas? Having just finished three years as Deputy Director of the National Park Service, it sure rings true for me! There wasn't a park issue that I dealt with that was precise, specific, defined, and consistent, and the superintendents didn't think so either.

So what about science in this kind of world with fuzzy logic, chaos theory, and diffusion filters? We need an explosion in capability. Our technical knowledge must get better. We have to define our technical research more clearly. We must monitor well, keep records well, and analyze the changes well–no difference from a decade ago. We have to do it better, not only so we know what we are talking about, but also so those through the diffusion barrier receive us with credibility, and we communicate results so that they can understand them.

Who's out there through the diffusion filter? What are their values? Do we understand them? Do they understand us? After all, what Teddy Roosevelt's peers thought about parks may not be what the population today feels. We have to know, and we have to relate our values to their needs for the future, and help them have the range of information so they can choose wisely. So, science about people, about vox populi, and the science of education of those whom we serve are essential.

If we are interested in protecting biological diversity and in ecosystem management, the Organic Act (1916) provides a good reminder. It reminds us that protection is associated with some sort of social pleasure, and that social pleasure, or satisfaction, is essential to the survival of these areas. Social pleasure or satisfaction includes, but is more than just direct interaction with, park resources. In a larger sense, it directly implies a cohesive acceptance throughout society that parks are of value. Can there be any doubt that the 21st century will bring more controversies and problems? We will still be asking: how do we interpret the protection process, how does it affect human behavior, and how does it affect our ecosystems and cultures? Finally, we need protected area managers who are creative and can take good biological, physical, landscape, ethnographic, historical, paleontological, social, economic, and political sciences and use them in ways that few have the temerity, guts, or intellect to even try today.

Creativity based on good information of all kinds will be the basic requirement of the future. The logic will be fuzzy, the issues imprecise and vague, and the boundaries more diffuse than ever.

It's a huge challenge, but an exciting world, don't you think?

"Ridleys" continued from page 17

shore could someday become one of the most successful endangered species restoration projects ever conducted by the National Park Service and its partners. PS

Donna J. Shaver (donna_shaver@usgs.gov) is the Station Leader of the U.S. Geological Survey Padre Island Field Station at Padre Island National Seashore. John E. Miller is the former NPS Chief of Science, Resources Management, and Interpretation at Padre Island National Seashore.

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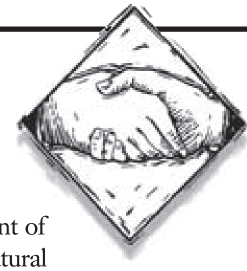
*Meetings of Interest**



March 13-17, 2000

The NPS Pacific West Region will host *West by Northwest 2000* in San Diego, California. The gathering will explore interdisciplinary management of parks and their resources with a specific look at natural and cultural resources stewardship and interpretation. Workshop themes include innovative program resolution, park futures and a changing public, and leading the way in resource stewardship. Contact Erv Gasser (206-220-4263), conference chair, for further information.

May 14-19

The Fourth International Conference on Science and the Management of Protected Areas (SAMPA IV) will be held at the University of Waterloo, Ontario, Canada. Held every three years, the international conference attracts a diverse group of parks and protected areas professionals, academics, researchers, managers, and members of nongovernment groups. Entitled *Learning from the Past, Looking to the Future,* SAMPA IV offers international plenary speakers, a wide variety of presentations and posters on contemporary issues, and educational field trips. Two major themes are planned: (1) regional approaches to planning and (2) research on both land-based and marine protected areas. Details of the conference, its programs, field trips, accommodations, and registration are available on the SAMPA website at http://landscape.acadiau.ca/sampaa/confpage.htm or by calling 519-622-9362.

May 16-18

The Third Conference on Research and Resource Management in the Southwestern Deserts will be held in Tucson, Arizona. Exploring the theme *Creative Cooperation in Resource Management,* the conference will feature papers and posters that tell of interagency collaboration in land use, research, resource management, and interpretation. Goals of the event are (1) to improve the preservation of natural and cultural resources through enhanced understanding of contemporary research and resource management challenges and (2) to achieve better cooperation through discussion of both ongoing and needed research. Abstracts for papers and posters will be accepted until January 14. Further information is available at www.srnr.arizona.edu/nbs, the home page of the USGS Sonoran Desert Field Station. Conference chair is Bill Halvorson (halvor@srnr.arizona.edu; 520-670-6885); registration coordinator is Lee Benson (602-640-5250, x 236; lee_benson@nps.gov).

October 16-20

The Natural Areas Association is planning its 27th annual conference, *Managing the Mosaic: Connecting People and Natural Diversity in the 21st Century,* to be held in St. Louis, Missouri. Celebrating the bicentennial of the Lewis and Clark Expedition, the banquet address will explore the historical and future implications of their trip, while plenary and concurrent sessions will focus on different aspects of biodiversity and how humans fit into the new century of management. Session topics planned include: insects in natural communities; economic values of natural diversity; monitoring; ecoregional planning; conserving caves, streams, and urban lands; partnerships; and many others. Further information is available from the Natural Areas website at www.natareas.org ("conferences" link) or from conference coordinator Kate Leary (573-751-4115, x183; learyk@mail.conservation.state.mo.us).

*Readers with access to the NPS Natural Resources Intranet Website can view a comprehensive listing of conferences and meetings at http://www1.nrintra.nps.gov/ (click "conferences and meetings").

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