National Park Service
U.S. Department of the Interior

Natural Resource Program Center
Office of Education and Outreach

P.O. Box 25287
Denver, CO 80225-0287

ISSN 1544-5429
D-1859/December 2007
www.nature.nps.gov/YearInReview

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Natural Resource Year in Review—2006

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Natural Resource Year in Review—2006

A portrait of the year in natural resource stewardship and science in the National Park System

Integrity

Understanding

Alliances

Action

Enjoyment

National Park Service
U.S. Department of the Interior

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"One of the great ironies of the American park system is that it was assembled without benefit of a blueprint. What we enjoy today has been stitched together over more than a century like a giant quilt—park by park—by the loving hands of thousands of people who wanted to save something precious for their children and grandchildren. In the words of former Park Service Director Russell Dickinson, 'It is hard to imagine how even a conscious plan could have achieved so much so well.'" — **Stewart L. Udall**

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Published by
National Park Service
U.S. Department of the Interior
Natural Resource Program Center
Office of Education and Outreach
P.O. Box 25287
Denver, Colorado 80225-0287

D-1859/December 2007

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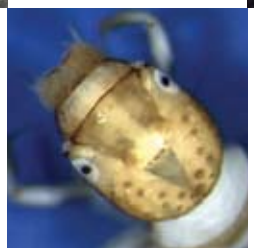

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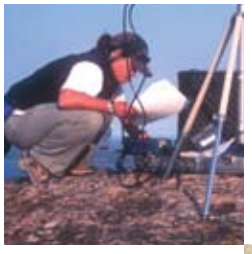

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The year 2006 in review

Twelve-year journey concludes with optimism and concern for the future of national parks

IN EACH EDITION OF *Natural Resource Year in Review* we have attempted to characterize the calendar year from the perspective of natural resource events in national park units. Our intent has been to illustrate the wide range of topics, issues, and pressures encountered each year while the National Park Service (NPS) strives to maintain national parks unimpaired for present and future generations. When I arrived in Washington from the Everglades more than 12 years ago, I felt it was important to keep an annual log of resource stewardship activities because of the cumulative nature of our progress—and our failures—in protecting park natural resources. While we can be proud of our successes, it is the sum of small failures that will compromise our National Park System.

On my watch I believe that our victories in protecting resources outnumbered our defeats. From the awe-inspiring flights of captive-bred and wild-born condors to reclaimed abandoned mine lands, we have documented many restoration projects and good management decisions in these 11 editions. Altogether the hundreds of articles indicate that prudent, science-based management can provide for the long-term integrity of national park resources. However, the number of demands on national parks and the kinds of decisions that must be made daily—often without much but the best judgment of park managers (which *can* vary)—do not afford certainty that this system can remain an untarnished and true reflection of America's natural heritage.

This is my last regular log entry, as I am retiring from federal service in 2007. Each year I have tried to summarize the things I saw happening across the National Park System and the major themes that surfaced during the year. This edition echoes predominant themes in our work to protect, understand, and celebrate the national parks. I want to use this space to recount some of the major accomplishments in natural resource management during this 12-year journey and bring attention to agenda items left undone.

I believe the Service must find a way to retain and benefit from the accumulated knowledge of long-term, in-park researchers, such as those whom we are losing with the retirement of the former NPS researchers who were transferred to the U.S. Geological Survey in 1993. We need to capture and access institutional memory more efficiently. We should again share that institutional knowledge with the world protected area community as we once did in the 1960s through the 1990s by reinstituting the International Short Course on Park Management. Finally, the National Park Service must become the intellectual hub for engagement in nature and for practical environmentalism in the local communities associated with the 391 units of the National Park System.

We have come a long way. In 1998 we finally got a clear acknowledgment—a mandate—from the Congress in passage of the National Parks Omnibus Management Act that research and monitoring are legitimate activities and requirements for the proper management of national parks. Using that mandate and the implications of Richard Sellars's 1997 *Preserving Nature in the National Parks*, we proposed a five-year program called the Natural Resource Challenge to bolster science-based park management. With capitalization on field expertise, expansion of successful prototype programs, and some new ideas, the Challenge found enthusiastic support in the Congress and among national park managers. More than 270 park units with natural resources now have basic inventories (11 databases, including vascular plants and vertebrate animals, on a GIS platform) of the resources they hold. More than 500 new science-based positions have been added to the National Park Service in support of parks, and resource managers now have an enhanced career ladder. Seventeen Cooperative Ecosystem Studies Units are now in operation, bringing the resources of more than 200 academic and nongovernmental organizations to bear on federal land management issues—at regional scales. Twelve federal agencies, including the National Park Service, have joined this system, which gives us access to research, technical support, and education in a cooperative partnership. We encourage all of these agencies to strive to understand the complexities of the resources they manage and to pursue their individual agency missions in a coordi-

nated, complementary way—the beginnings of ecosystem management. A system of 17 Research Learning Centers now supports academic researchers who wish to do research in a national park and share the results with visitors who are interested in science and parks. We now have 78 Canon National Park Science Scholars who have pursued doctoral research in national parks under a generous, merit-based scholarship program sponsored by Canon USA over the last 10 years. In the 11 editions of *Year in Review* we have documented the Park Flight Migratory Bird Program, the new National Cave and Karst Research Institute, a new Social Science Program, the All Taxa Biodiversity Inventory, benefits sharing, a new automated research permit system, Exotic Plant Management Teams, and much more. The National Park Service has made progress of which we all can be proud.

The biggest change in 2006 comes from the enthusiasm of Secretary Kempthorne for setting the stage for the 100th anniversary of the National Park Service in 2016. In his first year as Secretary of the Interior, he has championed the largest NPS base budget increase in our history and a target of $3 billion in new federal and private-sector funding by 2016. This effort, the *Centennial Challenge*, is, paraphrasing his words, "a big audacious idea" in step with the national park concept and the enduring support of the American public for national parks.

So, I leave with thanks to all contributors, editors, and readers of this log, and to all companions on this journey, and with great optimism for the future of national park resources and their appreciation and enjoyment by all.

Michael Soukup, PhD

Associate Director,
Natural Resource Stewardship and Science

October 2007

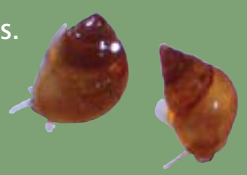
I leave with thanks to all contributors, editors, and readers of this log, and to all companions on this journey.

1 Protecting the Integrity of National Park Resources and Values

National parks represent a contract between Americans today and generations of Americans yet to come. As a nation, we have promised to leave these extraordinary places of discovery and power in a condition that is unimpaired so that they will continue to serve the needs of society to connect to authentic places for their educational, recreational, and restorative values. As citizens we look to the National Park Service to ensure that this ongoing commitment is undeterred and undiminished.

"The days of the past, when we could escape our workaday world for the pristine environment of our national parks, are being rapidly replaced by a world where preserving the national parks will depend more on what happens outside the parks than within them." —**Bob R. O'Brien**

Yet national parks today are evolving under influences that are not only the result of local park resource interactions but also consequences of human activities. Environmental factors both within and outside national park boundaries affect park values such as solitude, ecological wholeness, clean air and water, biodiversity, endemic species, healthy forests and fisheries, and educational and recreational opportunities. As the articles in this chapter and throughout this edition of *Natural Resource Year in Review* suggest, management can succeed in protecting the integrity of many park resources and values, though not in all cases or at all scales. For example, infestations of nonnative species are so vast and the spread of forest diseases often so rapid that treatments require prioritization to address the greatest needs and to make the best use of available staff and funds. Fortunately, one of the most precious values of the national parks is their ability to teach us about ourselves and how we relate to the natural world. This important role may prove invaluable in sustaining us as a species as we strive to uphold our national parks.



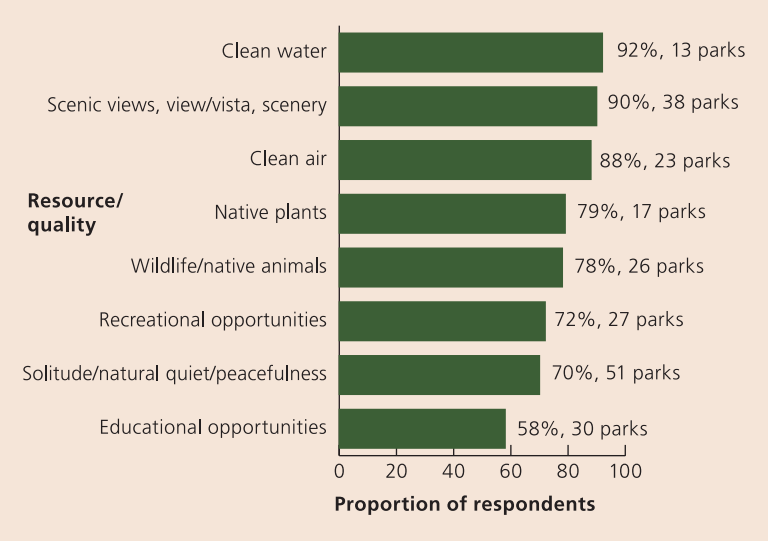
Visitor feedback offers invaluable insight for resource managers

By Lena Le, Margaret Littlejohn, and Steven Hollenhorst

IN 2006, USING THE MOST RECENT DATA, PARK managers across the country had the opportunity to "hear" visitor opinions on the importance of protecting park resources and values. Results of visitor studies conducted by the Visitor Services Project (VSP) show that visitors rated clean water, scenic views, and clean air as the most important resources in the national parks. Visitor groups selected by random sample were given a mail-back questionnaire as they entered a park and were asked to complete it after their visit. They rated the importance of protecting park resources, such as native plants and animals, historical buildings, and archaeological sites, in addition to those already mentioned. They also rated the importance of resources that enable them to enjoy their visit to national parks, including solitude/quietness, night sky, scenic views, recreational opportunities, and educational opportunities.

The Visitor Services Project began in 1982 when the National Park Service (NPS), recognizing the need to learn more about visitors and their opinions, asked the Park Studies Unit at the University of Idaho to develop a new approach to visitor studies. This ongoing feedback provides NPS managers with critical information. It helps them enhance visitor services, preserve the integrity of park resources and values, and accomplish their overall park management goals. From 1990 to 2005, the Visitor Services Project conducted 148 studies in national parks (with some parks having repeat studies), and averaged a 75% response rate. Each survey questionnaire was customized to provide visitor feedback on issues important to each park's managers.

Among the 148 studies, researchers selected 56 that contained the same question asking visitors to rate the importance of park resources. Since four parks had repeat studies, these 56 studies present visitor opinions from 52 parks. Visitors rated the importance of protecting park resources on a 5-point equal-interval scale, with 5 being "extremely important" and 1 being "not important." Although the question and scale remained the same, the items rated varied according to the presence of particular resources at each park. The comparable items included clean air, clean water, scenic views, native plants, native wildlife, recreational opportunities, educational opportunities, and solitude. Although 52 is a small number compared with the total of 391 units, these parks represent the variety of the National Park System in terms of unit size, type, available resources, and location. In addition, by aggregating opinions of more than 23,000 respondents, the data provide good representation of public opinions about the importance of protecting park resources.

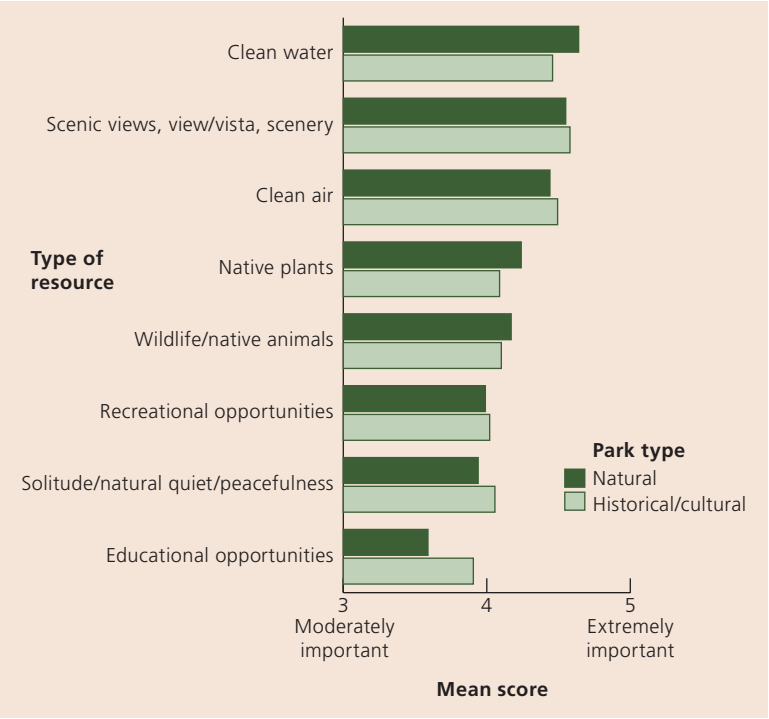


Combined percentages of visitors who rated various park resources as "extremely important" or "very important."

Overall, a sizable majority of visitors rated the protection of specific park resources as "extremely important" or "very important" (graph, above). In particular, 92% of respondents rated "clean water" and 88% rated "clean air" as "extremely important" and "very important," respectively. This shows that visitors are aware of, and support, the national park mission to protect these park resources.

For this analysis, parks were placed in two general categories—natural and cultural/historical—based on each park's primary resource. Regardless of park type, visitors demonstrated a similar pattern in the order of importance for resources selected. Clean air and clean water were of utmost importance. Scenic views and vistas are related to air quality in that visibility allows visitors to enjoy park scenery and preserved landscapes. This finding is evidence that visitors perceive recreational and educational opportunities as less important than protecting park values related to air quality, watershed, and native plants and animals (graph, next page).

Visitors rated clean water, scenic views, and clean air as the most important resources in the national parks.



Comparisons of mean score for importance ratings of park resources.

However, some differences by park type were evident. Natural resources (plants and animals) were perceived as more important in a natural setting than in a cultural or historical park. Cultural and historical parks were perceived as more important in providing educational opportunities to visitors than were natural resource–based parks. Nevertheless, the differences were not large in that many parks have both natural and cultural or historical resources.

Clearly, visitors who participated in these surveys understood the importance of global environmental resources such as clean air and clean water and, to a certain extent, native plants and animals. However, in contrast they perceived educational opportunities as relatively less important than the other resources listed in the graphs, especially in natural resource–based parks. Managers must consider many aspects of these complex issues, such as the costs and benefits of particular policy or management decisions relating to these resources. Nonetheless, these findings serve as general social indicators for managers of cultural and natural resources as well as for interpreters to contemplate as they strive to increase visitor awareness of critical park resources and issues. ■

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Commons without tragedy: Measuring and managing carrying capacity in the national parks

By Robert E. Manning

IN 1968, GARRETT HARDIN PUBLISHED A HAUNTING paper—"The Tragedy of the Commons"—in the prestigious journal *Science*. Now a foundational piece of environmental literature, the article portrayed national parks as an example of common property resources and described the tragic consequences of overuse. Since that time, annual visitation to the National Park System has nearly doubled and now approaches 300 million recreational visits per year. How many visits can the national parks ultimately accommodate without unacceptable impacts to park resources and to the quality of the visitor experience?

In the context of parks and related areas, this issue is often called carrying capacity. In recent years, the National Park Service (NPS), in consultation with academic and government scientists, has developed and applied a framework for addressing carrying capacity called Visitor Experience and Resource Protection (VERP). VERP starts with the development of management objectives (or "desired conditions") for park resources and for the quality of the visitor experience. These management objectives must ultimately be expressed in quantitative "indicators" and "standards." Indicators are measurable, manageable variables that are proxies for management objectives, and standards define the minimum acceptable condition of indicators. Under this procedural model, indicators are monitored and, when necessary, management actions are taken to ensure that standards are maintained. VERP has been applied in a number of diverse units of the National Park System, and the underlying conceptual framework of indicators and standards has now been adopted into the NPS general management planning process. Applications of VERP have been supported by a program of natural and social science research.

In 2006, studies at Muir Woods National Monument (California) provided an illustration of this research and planning approach. An initial survey of visitors to Muir Woods found that many respondents reported that the number of people encountered on park trails and the noise they made were important in defining the quality of the visitor experience. Thus these two variables are potentially important indicators of both resource and social conditions for the park. But what are appropriate standards for these variables? Subsequent phases of study addressed this question.

First, a series of computer-generated photographs of trail use was prepared and incorporated into a visitor survey. These six photographs showed a range of visitor use levels along a 75-foot (23-meter) section of trail (or typical "viewscape"). Survey respondents were asked to rate the acceptability of each photograph based on the number of hikers shown. Average acceptability ratings are shown in the graph. These data help provide an empirical basis for formulating a crowding-related standard. For example, average response scale values fall out of the acceptable range and into the unacceptable range at approximately 16 people per viewscape. Respondents were also asked to indicate which photograph they preferred to see, which photograph was so crowded that they would not return to Muir Woods, and which photograph showed the maximum level of use the National Park Service should allow. A computer simulation model of visitor use of the trail system was also developed to estimate the maximum daily use of the park without violating crowding-related standards on the trails.

In other studies, responses can vary depending on which questions are asked. For example, visitors' response to the maximum number of visitors the National Park Service should allow can be much higher than the number that is acceptable to the visitors themselves. This suggests that visitors understand that trade-offs exist between access to public areas and

These study photographs illustrate a range of trail use levels (i.e., persons-per-viewscape or PPV) at Muir Woods National Monument.

An initial survey of visitors to Muir Woods found that many respondents reported that the number of people encountered on park trails and the noise they made were important in defining the quality of the visitor experience.

protection of individual experiences and that they are willing to accept some level of use below their "acceptable" range in order to maintain public access.

Second, in an analogous way, a series of five 30-second audio tracks was developed that portrayed a range of visitor-caused noise in the park. These audio tracks were prepared from sound recordings taken in the park, and the audio tracks were incorporated into a visitor survey. Respondents listened to and rated the acceptability of each audio track. Findings suggest that most respondents feel that it is unacceptable to hear visitor-caused noise more than half the time they are in the park. These findings help to provide an empirical basis for formulating noise-related standards. Ongoing research is exploring the effectiveness of management efforts to reduce visitor-caused noise in the park, and preliminary findings are encouraging. (See the following article on the NPS Natural Sounds Program for more information on this and related research.)

The current work at Muir Woods is an extension of a program of research, planning, and management that has been conducted in many diverse units of the National Park System. Information has been developed on a range of indicators and standards, including trail, campsite, and river encounters; people per viewscape along trails; people at one time at attraction sites; waiting time for services and facilities; resource impacts on trails and at campsites; development of unofficial social trails; automobile traffic; type and level of facility development; litter and graffiti; size of hiking and tour groups; availability of parking; and visitor-caused noise.

This work has recently been summarized in a new book titled *Parks and Carrying Capacity: Commons Without Tragedy*, published by Island Press. This work has been conducted by a number of planners, managers, and researchers inside and outside the National Park Service. The book suggests that we now have the conceptual foundations, an associated planning and management framework, a growing set of supporting research approaches, an array of management practices, and a number of encouraging case studies that allow us to engage carrying capacity more deliberately. In other words, we can have commons, including national parks, *without* tragedy. Of course, applying these planning, management, and research approaches will be challenging and sometimes even contentious. Failure to do so, however, would likely result in issues that are even more difficult or impossible to resolve in the future. ■

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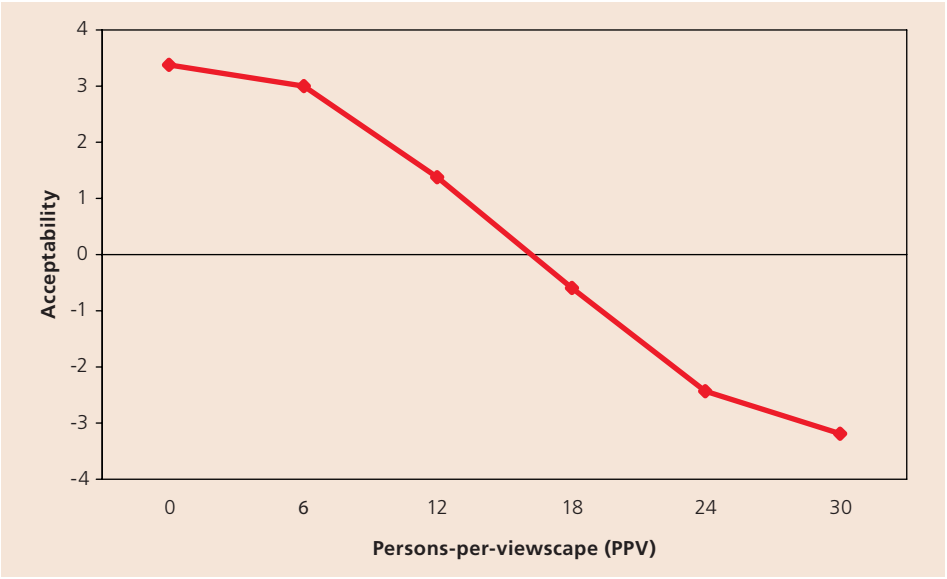

Social norm curve for trail use levels at Muir Woods National Monument.

Advancing air tour management plans and protecting soundscapes in national parks

By Karen Trevino

SOUNDS HAVE A POWERFUL EFFECT ON HUMAN emotions, attitudes, and memories and enhance the ability to process, comprehend, and understand the world. Hearing and being heard are also important for wildlife because many animals depend on acoustic communication for finding food, avoiding predators, establishing territory, courting and mating, and nurturing young. For the National Park System, however, a healthy acoustic environment is not limited to the sounds of nature; cultural and historical sounds are also significant components. The sound of a cannon shot echoing across a Civil War battlefield and the hypnotic drumbeat of a sacred tribal dance bring the past to the present and elicit a sense of relation to our ancestors. The sounds of people enjoying the parks through a variety of recreational activities are also a common element of the soundscape in national parks.

Officially established in 2000, the National Park Service Natural Sounds Program provides park managers with

As part of the air tour management planning process for Mount Rushmore National Memorial (South Dakota), the Natural Sounds Program and the John A. Volpe Center installed monitoring equipment to collect acoustic data. The draft environmental assessment, part of the air tour management plan for the memorial, is nearly completed. However, the FAA and National Park Service need to resolve differences in methodologies for assessing impacts, including analyses of visitor security and the potential for air tour noise to interfere with various types of communications (e.g., visitor conversations, public speeches, interpretive programs, and safety announcements).

Development of the air tour management plan for Kalaupapa National Historical Park (Hawaii) was indefinitely suspended after commercial air tour operators withdrew their applications for interim operating authority. The FAA confirmed that air tour operators did not intend to conduct air tours over the park, and all commercial operations ceased by January 2007. It is unlikely an air tour operator could apply for operating authority over Kalaupapa in the future and the planning process would start again.

technical assistance and national policy development and guidance for a consistent approach to managing acoustic environments. In 2006 the Natural Sounds Program assisted 39 parks with data collection and analysis, monitoring, and planning. Developing soundscape goals, objectives, and standards and identifying appropriate measures for mitigating noise impacts are part of the planning process.

Integral to the Natural Sounds Program is working with the Federal Aviation Administration (FAA) to provide the necessary tools for implementing the National Parks Air Tour Management Act of 2000. The National Park Service and the FAA jointly develop air tour management plans for all parks with commercial air tours. Currently 106 National Park System units have commercial air tours; other areas will need plans whenever an air tour operator requests to fly within 0.5 mile (0.8 km) of a park's boundaries. Air tour management plans determine the most effective means for safety and environmental protection with the least impact to the air tour industry and park resources. Plans determine if, when, or where commercial air tours will occur over National Park System lands, specifying flight routes, direction, minimum altitudes, time of day, and number of flights. Planning involves many steps: acquiring acoustic data, which must be completed a year before beginning work on an air tour management plan in order to capture seasonal differences; characterizing the ambient acoustic baseline; analyzing impacts to park resources and visitor use; overseeing contractors; providing scientific expertise for soundscape management; administering the NPS obligation of funding 40% of all air tour management plans; implementing quiet technologies; and executing the recommendations of the National Parks Overflights Advisory Group.

To date, park and program staffs have collected acoustic data in 20 of the 106 parks with air tours. Voluntary

agreements regarding overflights exist in 5 parks. Kickoff meetings among FAA, Natural Sounds Program, and park staffs have taken place in 16 parks, and development of air tour management plans is under way in 5 parks (i.e., Hawaii Volcanoes, Haleakala, Badlands, and Grand Canyon national parks, and Mount Rushmore National Memorial). In addition the National Park Service worked closely with the FAA and congressional committees to amend the 2000 act to give park superintendents more flexibility in the development of air tour management plans.

Supporting acoustic research and technology development is another component of air tour management planning because federal mandates direct the National Park Service to use the best available science and technology in making management decisions. The National Park Service uses noise metrics and analysis protocols that assess, mitigate, and prevent impacts on park resources and visitor enjoyment. The Natural Sounds Program is in the process of improving existing metrics and in some cases developing new metrics more aligned with NPS management objectives. Program staff is pursuing technical peer review from the Federal Interagency Committee on Aircraft Noise and publishing the improved and new metrics in relevant acoustic journals.

The Natural Sounds Program continues to develop reliable, innovative, cost-effective technologies for collecting acoustic data that can be deployed, monitored, and maintained with minimal staff time and resources. Program staff developed user-friendly monitoring software so park staff and volunteers could help maintain equipment without extensive training. The Natural Sounds Program is developing automatic signal processing that will increase the efficiency and speed of analyzing data. The data obtained from the monitors now run through several scripts to produce a spectrogram, providing a quick visual analysis of a day's worth of acoustic data. To further reduce both the cost of analysis and the time required to provide park managers with a final report, much of the data visualization is automated. Furthermore, because of a more efficient data logger, third-generation acoustic monitoring stations now in use consume only about one-fifth of the power of previous stations. Investigators can also monitor previously inaccessible areas (e.g., dense forest and areas with heavy rainfall) because solar panels are no longer required.

Air tour management plans determine the most effective means for safety and environmental protection with the least impact to the air tour industry and park resources.

Given the inextricable link between natural and culturally appropriate sounds and overall park experience, the NPS Natural Sounds Program is working closely with several universities to study the relationship between visitors and soundscapes. In Muir Woods National Monument (see previous article) investigators from Colorado State University and the University of Vermont conducted surveys to determine acceptable levels of human-caused sound. Colorado State University also carried out listening exercises in Yosemite and Grand Teton national parks to understand visitor perceptions about sound sources in parks. Virginia Polytechnic Institute will be conducting similar surveys and listening exercises in Haleakala and Hawaii Volcanoes national parks and has already begun research on the effects of noise generated by hikers in Great Smoky Mountains National Park. The latter study includes the development of a computer model that simulates both visitor traffic and the noise it generates. Additionally, Southern Utah University conducted surveys in Bryce Canyon National Park to examine the relationship between the acoustic experience and the psychological responses of visitors. More research is expected for the 2007–2008 season. ■

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Springs and seeps: Inventories provide data on at-risk wetland resources in Mojave Desert Network parks

By Debra Hughson, Terry Fisk, and Don Sada

IN THE ARID EXPANSES OF THE MOJAVE DESERT (California and Nevada), various scattered seeps, springs, and small riparian areas support endemic aquatic biota, rare plants, and wildlife. They also provide an invaluable source of water for human use and are, in turn, greatly impacted by such use. In 2006, through a cooperative agreement, the Desert Research Institute, the Great Basin Institute, and the National Park Service began exhaustive inventories of these "desert water holes" to evaluate their overall health using a protocol developed for the Mojave Network Inventory and Monitoring (I&M) Program (Sada and Pohlmann 2006). Focusing on groundwater and surface water dynamics, in part because of the vital connection between spring discharge and groundwater levels, which are susceptible to impacts from groundwater pumping, researchers collected basic data on springs, including brook length, spring type, approximate discharge, temperature, and substrate composition.

Drawing upon combined resources and technical staff, national parks across the nation have formed networks to better monitor and inventory ecosystems and identify critical indicators of ecological health, called vital signs. The Mojave Network includes Great Basin National Park (Nevada), Death Valley National Park (California and Nevada), Lake Mead National Recreation Area (Nevada and Arizona), Grand Canyon–Parashant National Monument (Arizona), Mojave National Preserve (California), Joshua Tree National Park (California), and Manzanar National Historic Site (California). For parks in the Mojave Network, water quantity and quality are vital signs because their condition is sensitive to increased regional water use and development outside the parks. For this project, staff surveyed 630 springs in Death Valley National Park, 80 in Lake Mead Recreation Area, 228 in Grand Canyon–Parashant National Monument, and 156 in Joshua Tree National Park. Great Basin National Park had already completed its inventory of 210 springs, Mojave National Preserve is completing its inventory of 183 springs, and Manzanar National Historic Site has no springs.

Based on the extent of the aquifers that supply their flow, springs in the Mojave Network are characterized as local or regional. Local springs are fed by recharge from within a local watershed, have a water temperature typically reflecting the annual mean temperature of that watershed, and are found at higher elevations than regional springs. These springs may be intermittent and, as a general rule, are not persistent over long periods of geologic time. By contrast, regional springs discharge from extensive aquifers that cover tens of thousands of square miles and can underlie many local watersheds. These springs are typically warm because of deep circulation. They can also discharge appreciable volumes of water and, most importantly, are persistent through geologic time—tens of thousands to perhaps millions of years. Because of this persistence, they are characterized by rich species diversity and high levels of endemism.

Death Valley alone has 521 springs, ranging from marshlands along the Amargosa River to numerous intermittent mountain-front seeps. The Saline Valley and Panamint Valley portions of Death Valley National Park add 57 and 51 more springs to the park's database, respectively. Most springs in Death Valley lie below 4,200 feet (1,280 m) in elevation and discharge less than 26 gallons/minute (100 liters/minute). Spring brook lengths are typically less than 656 feet (200 m). However, some springs discharge several hundred or more gallons per minute and have spring brook lengths

Saratoga Springs lies in southern Death Valley National Park near the course of the intermittently flowing Amargosa River. Five rare invertebrate species and Saratoga Springs pupfish (*Cyprinodon nevadensis nevadensis*) live here. Water resources are invaluable to Mojave Network parks, and such baseline information on water quality and quantity enables managers and staff to better protect these resources in the face of groundwater development.

Great Basin Institute staff inspects a spring in an abandoned shaft near the Keane Wonder mine in Death Valley National Park. Some riparian vegetation can be seen beyond the signpost.

Rogers Spring at Lake Mead National Recreation Area, one of two refugia for the leopard frog.

National Park Service and USGS scientists collect water quality data at a vernal pool in the Grapevine Springs area of Death Valley National Park.

The future of Mojave Network park springs and their rare, endemic biota is uncertain in the face of climate change and human enterprise. Inventories of springs and aquatic biota in the desert parks provide knowledge to inform the public of these at-risk resources.

up to 3 miles (5 km) long. Because of impacts from natural events and human activities, about 70% of the area's springs are in a moderately to highly disturbed state, which is critical in that a significant fraction of these water bodies supports a unique assemblage of desert aquatic biota, including several species of fish. The most famous, the Devils Hole pupfish, is now down to a double-digit population. Other aquatic macroinvertebrates (mollusks, aquatic insects, and crustaceans) and rare plant communities are found only in these springs. A number of the springs in Lake Mead National Recreation Area that support significant riparian resources are fed by the same regional carbonate aquifer that is exposed in Devils Hole. One of two distinct populations of the endemic leopard frog (*Rana onca*) occurs only in Blue Point Spring and Rogers Spring. Mojave Network springs are also important as water sources for terrestrial animals and support riparian systems that are important nesting sites for birds.

Most springs in the West have been altered by livestock, feral horse, and burro trampling, as well as by surface diversions (e.g., spring boxes, pipes, troughs, and dredging). Crayfish, nonnative fish, and mollusks, introduced for recreation, mosquito control, and by accident, also impact the springs. In Grand Canyon–Parashant National Monument, nearly all springs have been highly modified by humans, primarily for use by livestock. More than 100 springs in Mojave National Preserve were once diverted for livestock watering. More recently, however, the regional carbonate aquifer that supplies springs in Death Valley and Lake Mead has been a focus of concern. Plans for continued urban growth in Clark County, Nevada, have led the Southern Nevada Water Authority to seek additional water supplies within the state but outside of Clark County to supplement the meager Colorado River allotment given to them under the early 20th-century Colorado River agreements. Spring Valley, situated on the west side of Great Basin National Park in east-central Nevada, and Three Lakes and Tikapoo valleys, situated northwest of Las Vegas, are sites of the latest groundwater rights granted to the city. These and other pending applications in eastern and southern Nevada may someday impact springs in Great Basin National Park, Lake Mead National Recreation Area, and Death Valley National Park. Groundwater extracted from pumping wells must eventually be derived from intercepted natural discharge, with the relevant questions being how long until the effects are noticeable and what effects society is willing to accept. Inevitably, water drawn from wells will lower groundwater levels, which will adversely impact areas of natural discharge, including, perhaps, springs inside national parks.

Drought years also affect spring discharge. In the Mojave Desert and Great Basin national parks, almost all recharge to aquifers occurs as precipitation above 6,000 feet (1,830 m). Longer periods of drought in the Southwest, occurring as a result of climate change, will likely decrease the overall volume of recharge. An investigation into the susceptibility of three springs in the Mojave Network to climate change and groundwater development is currently under way through a USGS-NPS Water Quality Partnership. Specifically, the study is looking at water quality–discharge relationships as they affect amphibian populations.

The future of Mojave Network park springs and their rare, endemic biota is uncertain in the face of climate change and human enterprise. Inventories of springs and aquatic biota in the desert parks provide knowledge to inform the public of these at-risk resources. The timing and magnitude of changes to aquatic resources remain unknown. Monitoring at key locations will improve our understanding of Mojave spring ecosystems and our ability to manage the risks. ■

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Water quality monitoring assessment of four park units on the Colorado Plateau

By Charlie Schelz

IN THE HIGH DESERT OF THE COLORADO PLATEAU, water means life. Surface water in seeps and springs, streams and potholes, and the Colorado and Green rivers usually proves adequate to support plants and animals adapted to this arid environment, but a variety of circumstances can upset the delicate balance of water quantity and quality. Threats include climate change, changes due to drought or high-intensity storms, vehicles traveling within stream channels, groundwater pumping and contamination from domestic and industrial wells, and upstream disturbances that might include septic system discharges or runoff from agriculture, roads, off-road vehicles, energy development, mining, new housing, or livestock grazing. Tracking onetime events and long-term trends, either human-induced or natural, provides information about this critical resource that can make the difference between life and death in the desert.

Canyonlands National Park, Arches National Park, Hovenweep National Monument, and Natural Bridges National Monument, known collectively as the Southeastern Utah Group, monitor water quality and quantity in each of those parks. Monitoring began in 1983, conducted by Division of Resource Management staff in cooperation with park river rangers, and is now supported by the National Park Service (NPS) Inventory and Monitoring Program, the NPS Water Rights Division, the U.S. Geological Survey, and the State of Utah Division of Water Quality. Samples are

Seeps, springs, and rivers are the lifeblood of the desert, bringing critical moisture to a parched landscape. A program of water quality and quantity monitoring is designed to track conditions of this important resource in four national parks in southeastern Utah.

A four-wheel-drive route in Peekaboo Spring is one of a number of water quality monitoring sites in the Needles District of Canyonlands National Park.

monitored for a wide range of chemical parameters, aquatic macroinvertebrates, and fecal indicator bacteria. Water quantity or flow is also measured. Results of chemical testing are made available via the Internet in the national STORET system managed by the United States Environmental Protection Agency (www.epa.gov/storet/dbtop). A detailed analysis of trends from 1994 to 2004 is available in reports for each park.

Water quality in the four park units usually ranges from good to excellent, though temporary surges in some chemicals or conditions have occurred as a result of extreme weather. Elevated numbers most commonly reflect total phosphorus and manganese in seeps and springs that exceeded primary drinking water standards. Dissolved solids exceeded secondary drinking water standards at many of the sites monitored. Total suspended solids and turbidity exceeded standards numerous times at all sites on the Green and Colorado rivers. Excess aluminum, sulfate, and selenium are also problems at river sites.

In Salt Creek in Canyonlands National Park, elevated levels of fecal indicator bacteria, turbidity, total suspended solids, and water temperature are apparently the result of vehicles traveling in the stream channel. Most of the four-wheel-drive route in Salt Creek was closed in 1998 as a result of a lawsuit brought by a consortium of environmental groups against the National Park Service. Unpublished program data clearly show an impact on water quality at Peekaboo Spring in the section that remains open. In addition to the impacts noted above, aquatic macroinvertebrate species diversity appears to be about 25% lower than that in similar sites without vehicle access.

In the program's early stages, observations and crude measuring techniques provided estimates of water quantity. Over the years, a better understanding of the extreme ecological importance of the amount of available water led the NPS Water Rights Division and hydrologists from the U.S. Geological Survey and the State of Utah to assist the parks in developing more accurate methods of measurement. In Colorado Plateau parks, seeps and springs represent some of the most ecologically significant and endangered habitats, even though they constitute less than 1% of the land surface. Accurate measurements of water quantity and ensuring continuation of water flow rights are necessary to protect these and other critical natural resources on the Colorado Plateau.

Tracking onetime events and long-term trends, either human-induced or natural, provides information about this critical resource that can make the difference between life and death in the desert.

The lack of available funding for measuring water flow has limited this extremely important monitoring to a few springs and seeps in Arches National Park and in Hovenweep National Monument. Much more monitoring should be done in both parks. Monitoring baseline flows for these systems helps to anticipate potential effects of flow alterations in the future. Since 2000, a slight downward trend in the springs and seeps along the western boundary of Arches National Park coincides with recent commercial and domestic development, stimulating concern that domestic and industrial water wells may draw down the groundwater aquifer or that sewage from septic systems may contaminate surface water. This downward trend may be a natural result of the recent drought the area has experienced, or it may be influenced by human activities. The National Park Service has identified adjacent land development as a serious threat to water quantity and quality; only continued monitoring would answer these questions and provide guidance for the future. ■

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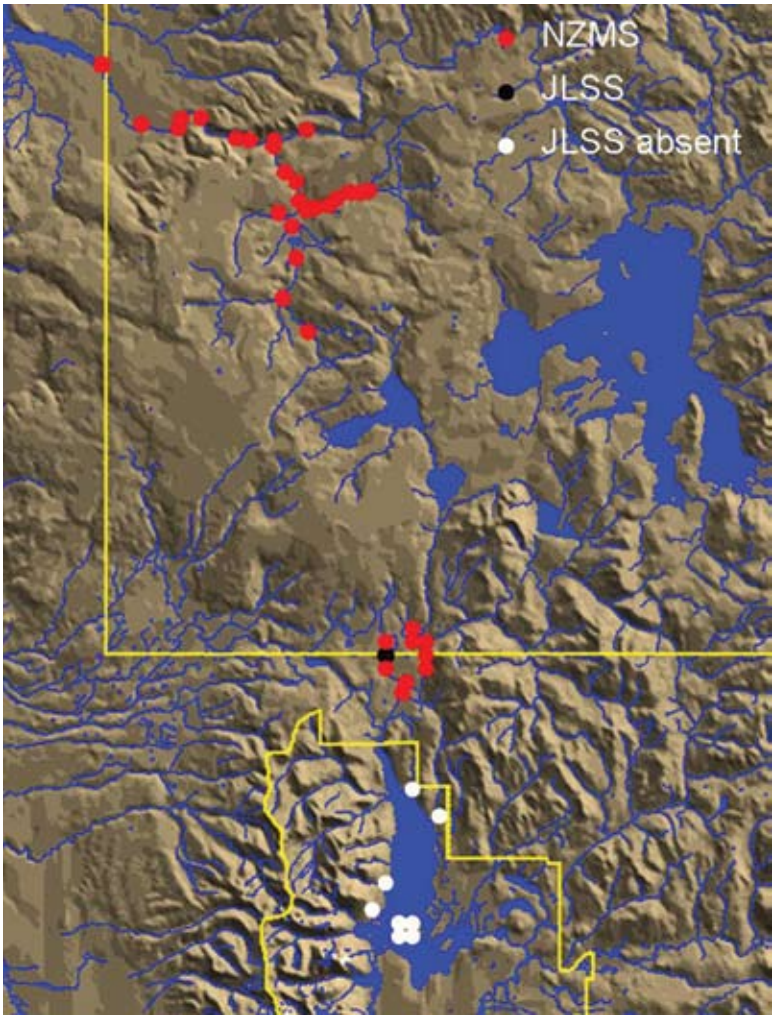
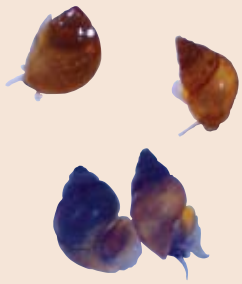
Invasive snail poses threat to endemic species in Greater Yellowstone

By Leslie Riley, Mark Dybdahl, Susan O'Ney, and Kathy Tonnessen

THE JACKSON LAKE SPRING SNAIL (*Pyrgulopsis robusta*) is presently known from only a single small stream near the boundary between Grand Teton and Yellowstone national parks (Wyoming). This snail is similar to other spring snails in the genus *Pyrgulopsis*, which are scattered in a few isolated populations across the Snake River and Columbia River watersheds. However, the Jackson Lake spring snail is a distinct population both geographically and morphologically. Its historical range included springs in the upper Snake River watershed above Jackson Hole, Wyoming. One of the last documented collection sites before 1975 was Elk Island in Jackson Lake.



Survey results show that the range of the endemic Jackson Lake spring snail (JLSS) is restricted to a small portion of its historical range. Within the present range, competition from the invasive New Zealand mudsnail (NZMS) threatens to reduce the Jackson Lake spring snail population.



The endemic Jackson Lake spring snail (*Pyrgulopsis robusta*; at top in the photo pairs) and the invasive New Zealand mudsnail (*Potamopyrgus antipodarum*; at bottom) can be difficult to distinguish in the field; however, the Jackson Lake spring snail is wider for its length.

Historically, the main pressure on the survival of this endemic snail was the damming of Jackson Lake and associated habitat modifications. Within its present range, however, the recent arrival of the invasive New Zealand mudsnail (*Potamopyrgus antipodarum*) might pose a new threat to the continued existence of the Jackson Lake spring snail. The current range of the endemic spring snail is restricted to a small portion of the historical range where it now competes with the nonnative mudsnail. In 2005, researchers from Grand Teton National Park, the University of Wyoming, and Washington State University explored the historical range of the Jackson Lake spring snail but found no refuge populations. These investigators will continue to search for the Jackson Lake spring snail in unexplored pockets of Jackson Lake and nearby thermally influenced springs.

Aquatic nuisance species have become a major concern for preserving the integrity of natural resources in many areas of conservation significance, including Grand Teton and Yellowstone national parks. The New Zealand mudsnail, a worldwide freshwater invader, has infested the habitat of a number of endemic spring snails listed as threatened or endangered in the intermountain West. The distribution of the New Zealand mudsnail is widespread and completely overlaps the remaining narrow range of the Jackson Lake spring snail. The spring snail is now rare in one of its last strongholds—Grand Teton National Park. Study results in 2006 by Bob Hall from the University of Wyoming and others show that the mudsnail population exists there at extremely high densities (>500,000 snails/m^2). The superior competitive ability of the mudsnail is threatening coexistence. In field experiments, New Zealand mudsnails grow faster than Jackson Lake spring snails under all conditions. Moreover, interactions with the spring snail have

Though investigators will continue searching for refuge populations, as of 2006 the Jackson Lake spring snail was known from one small tributary that runs between Grand Teton and Yellowstone national parks in Wyoming.

positive effects on mudsnail growth, while Jackson Lake spring snail growth is reduced in the presence of the New Zealand mudsnail.

Although the presence of the mudsnail slows the growth of the spring snail, strong evidence for competitive displacement of the Jackson Lake spring snail is not yet apparent and could take years to manifest. Investigators have monitored yearly variation in populations of the two species from 2001 through 2005 at five sites where both species are present. Samples collected in summer 2007 will help determine whether spring snail densities are indeed responding in a predictable manner to changing abundance in the mudsnails. Only continued monitoring will reveal how this native population will respond to a competitive invasive species.

The value of this research extends beyond the boundaries of Grand Teton and Yellowstone national parks and involves an array of federal, state, and private land managers who are striving to protect the valuable fisheries, water quality, and aquatic ecosystems of the Rocky Mountains. Basic research on the interactions between the introduced and native snail species was made possible through a collaboration of several partners with the Rocky Mountains Cooperative Ecosystem Studies Unit (CESU). This research, funded by the Greater Yellowstone Coordinating Committee, the Natural Resource Preservation Program, and the National Science Foundation, will enable managers in the Greater Yellowstone Ecosystem to understand the ecology of these competing snail species, devise management strategies to control the spread of the New Zealand mudsnail, and preserve remnant populations of the native spring snail. ■

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Strategies for saving hemlocks in the imperiled forests of three West Virginia national parks

By John Perez

ONE OF THE MOST DIFFICULT ISSUES A LAND manager may face is the imminent loss of a species. But that is exactly what biologists expect to happen in the next 5 to 10 years now that the highly destructive hemlock woolly adelgid (*Adelges tsugae*) has infested the hemlock (*Tsuga canadensis*) forest of the three national park areas in southern West Virginia: New River Gorge National River, Gauley River National Recreation Area, and Bluestone National Scenic River. Hemlocks within the three parks form almost pure stands along many high-gradient stream corridors, and are frequently found as codominant canopy trees on 10,190 acres (4,126 ha). The hemlock is a keystone species within the Gauley River National Recreation Area, comprising 35% of the forest canopy, including outstanding examples of old-growth forest approaching 350 years in age.

Resource managers expected the adelgid threat several years ago, and in 1999, staff at New River Gorge secured funding to establish thirty-six 400-square-meter (4,306 sq ft) long-term monitoring plots. These plots have furnished seven years of critical pre-infestation data on the hemlock ecosystem prior to the arrival of the first hemlock woolly adelgid in 2004. This important data set is now being used by researchers studying ecological changes to the hemlock forest of the eastern United States. In 2005, entomologists from the USDA Forest Service, Forest Health Protection, Morgantown, West Virginia, conducted field surveys and prepared a biological evaluation that included a range of options to combat the infestation. No overall solution for the hemlock woolly adelgid pest problem is available, and pesticide treatments are effective only on individual trees. Therefore, the prognosis for the survival of the eastern hemlock ecosystem is very grim.

The Kioritz soil injector delivers insecticide around the roots of a hemlock tree threatened by hemlock woolly adelgid.

The Tree IV stem injection system is used instead of soil injection where insecticide must be kept away from waterways, where it would harm aquatic organisms.

Hemlock woolly adelgid populations are known to increase rapidly, with tree mortality occurring within 3 to 10 years of initial infestation. Therefore, park managers made a decision to aggressively implement all the recommendations in the biological assessment, and were successful in obtaining a $58,000 grant from the Forest Service. Areas identified for treatment in 2006 included old-growth forests, rare species habitat, sensitive aquatic resources, and high visitor-use areas. A three-member West Virginia Civilian Conservation Corps crew treated more than 1,533 trees on 534 acres (216 ha). They soon discovered that the use of the Kioritz soil injector (see photo) was the most effective method of insecticide application. The crew was able to treat about two dozen trees in the same time it took to

No overall solution for the hemlock woolly adelgid pest problem is available, and pesticide treatments are effective only on individual trees. Therefore, the prognosis for the survival of the eastern hemlock ecosystem is very grim.

complete a single stem injection. However, stem injections are the only authorized method of application in such areas as streambanks or wetlands, where insecticides have the potential to impact aquatic organisms. In addition, stem injections were used on trees located along cliff tops and in boulder fields, where soil injection was not possible. The Tree IV stem injection system (see photo) delivers insecticide directly into the sapwood (xylem tissue) but is less effective than the soil injections, which are viable for three or more years.

Without intervention, impacts to the hemlock ecosystem would certainly rival the loss of the American chestnut of the early 20th century. As the hemlocks disappear from the ecosystem, they will likely be replaced by early successional hardwood species. In Virginia, 90% of the hemlocks in Shenandoah National Park and along the Blue Ridge Parkway are already gone (see photo). Chemical insecticide treatments, though effective, are conducted on an individual tree basis, which is both labor-intensive and costly. Thus treatments are limited to those areas with outstanding biological resources or other high-value sites. The use of biological controls offers the best hope for long-range survival of hemlocks on a landscape scale. In 2006 the park released two species of predatory beetles (*Sasajiscymnus tsugae* and *Laricobius nigrinus*) in remote areas of old-growth forest.

We hope these efforts will have some effect in suppressing the infestation. In addition to aggressively treating as many hemlocks as possible, park staff will continue to inventory the 36 long-term monitoring plots and document changes in the hemlock forest. Though the future of the hemlocks does not look promising, park staffs will continue to examine the long-term monitoring plots for some indication that this outstanding element of our Appalachian ecosystem will not be lost. ■

Before hemlock woolly adelgid infestation, this was a fine hemlock stand at Shenandoah National Park.

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Merging ozone, plant leaves, science, and outreach

*By Colleen Flanagan, Robert Kohut, Ellen Porter, and Jennifer Stingelin Keefer**

BLEND FIVE NATIONAL PARKS, VEGETATION MAPS, experts in plant pathology, poor air quality, and ozone-sensitive vegetation such as common milkweed, tulip poplar, and cut-leaf coneflower. Garnish with hand lenses, tree climbers, scientists, volunteers, and a Research Learning Center. Sweeten with a dollop of trial and error and the result is the summer 2006 multi-park pilot assessment of foliar ozone injury.

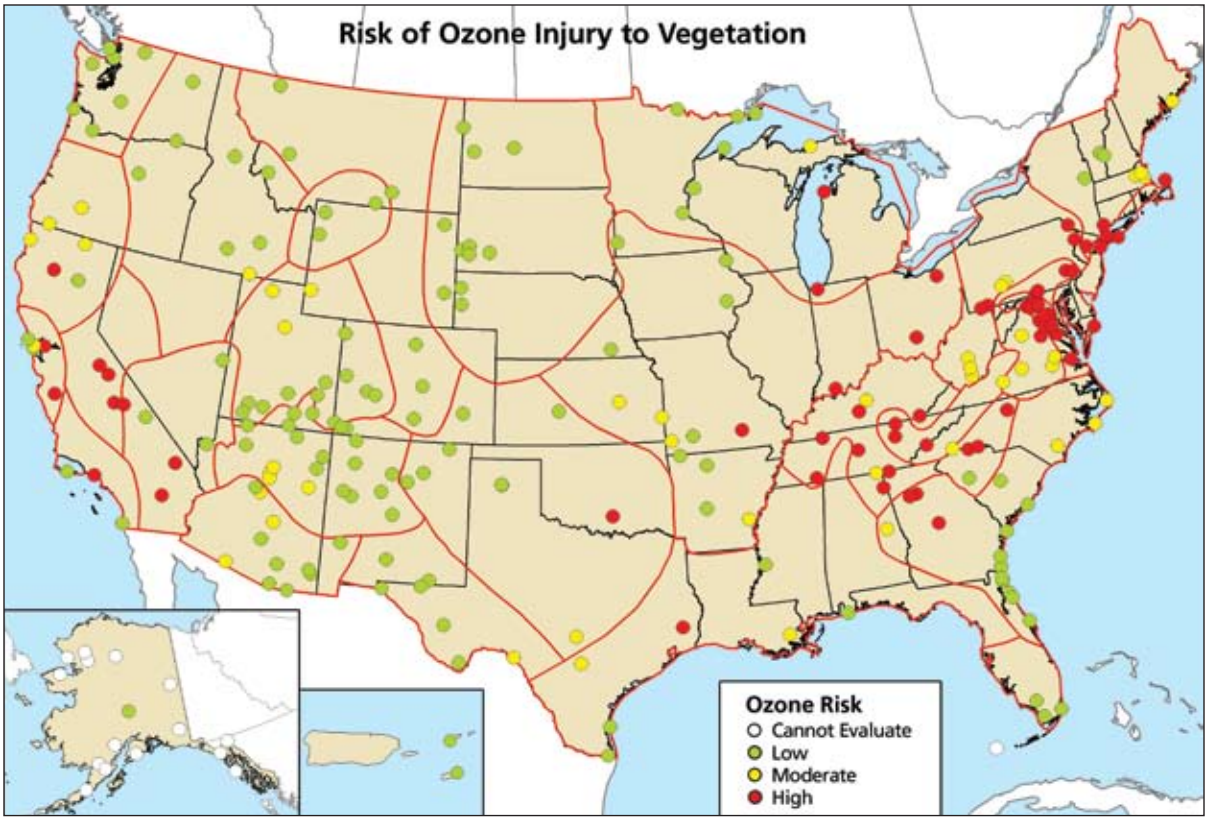
National parks that participated in the study were Allegheny Portage Railroad National Historic Site (Pennsylvania), Cowpens National Battlefield (South Carolina), Cumberland Gap National Historical Park (Kentucky), Mammoth Cave National Park (Kentucky), and Rocky Mountain National Park (Colorado). The objectives of the field program were to determine how well the *Handbook for Assessment of Foliar Injury on Vegetation in the National Parks*, developed by Dr. Robert Kohut of the Boyce Thompson Institute at Cornell University and the NPS Air Resources Division, served park staffs as they selected plant species to monitor, established field plots, and performed assessments of foliar ozone injury.

The handbook was extensively tested in each of the five parks from June to August 2006, and program participants gained insight into the changes and additions that will increase its utility. Each of the parks established an ozone injury assessment program, collected one year of data, and documented the presence of foliar ozone injury. Though overall it was a very effective resource, the handbook at times required the users to adapt the protocols to their specific park conditions. The field trials demonstrated problems associated with assessing leaves on trees that reach heights of more than 100 feet (31 m) (Mammoth Cave), the lack of plots with enough plants to meet handbook criteria (Allegheny Portage), and variation in the appearance of foliar ozone injury (Rocky Mountain). These and other issues illustrate the difficulty in developing a scientific "recipe book" applicable to all national parks in the 32 Inventory and Monitoring (I&M) networks, and confirm the need to employ sound scientific practices when a protocol is modified to meet specific field conditions.

Ozone, produced by photochemical reactions in the atmosphere involving emissions from combustion of fuels and other sources, can travel long distances, and occurs in high concentrations even in remote, rural areas—like national parks. It is especially highly concentrated in the eastern United States and in California, but ozone is also increasing in western states. In addition to harming human health, ozone harms plants. Ozone bioindicators, plant species that display distinctive visible leaf injury resulting from ozone exposure, act as sensitive warning systems of potential impacts of ozone on plant communities. Most national park units contain one or more bioindicator species. Lists, by park, of bioindicator species are available from NPSpecies, an NPS database of national park biodiversity.

A symptom of ozone injury—stipple—as found on common milkweed (*Asclepias syriaca*) at Allegheny Portage Railroad National Historic Site. This bioindicator was also used at Cumberland Gap National Historical Park and Mammoth Cave National Park during the 2006 surveys.

Ozone can produce both visible foliar injury (e.g., stipple and chlorosis; see photo) and growth effects (e.g., premature leaf loss and reduced photosynthesis) in plants. Though ozone does not kill plants, it stresses and weakens them over time. Ozone enters plants through leaf openings called stomata and oxidizes plant tissue, causing changes in biochemical and physiological processes. These changes result in less carbon for growth and reproduction, and less carbon to allocate to storage in the roots for overwintering. Seed production and germination potential may also be reduced, with possible population-level effects. Over several years, these effects have a cumulative impact on the plant, reducing its vigor and making it more susceptible to insects and pathogens.



Risk of ozone injury to vegetation in the 270 national parks (dots) located in the 32 I&M networks (red lines).

Foliar ozone injury was found on bioindicator plants in each of the five parks that participated in the pilot assessment. Previously, ozone injury had been documented in other national parks, including Acadia (Maine), Great Smoky Mountains (North Carolina/Tennessee), Shenandoah (Virginia), Sequoia/Kings Canyon (California), and Yosemite (California). A risk assessment completed by Dr. Kohut and the Air Resources Division (2003–2005) concluded that about 28% of 270 parks in the I&M networks were at high risk of ozone injury. Most of the parks at risk are clustered in the mid-South, mid-Atlantic, and southern California regions (see map).

Measuring ozone bioindicator health provides information about the condition of park vegetation that management can use to influence regional air pollution control programs. Ozone injury monitoring data can also be used to inform and educate the public about the consequences of elevated ozone levels. The Appalachian Highlands Science Learning Center, for example, has incorporated ozone injury monitoring into middle school educational programs (http://www.nps.gov/archive/grsm/pksite/index.htm). Budgetary and time constraints will affect whether ozone injury assessments will continue at the five pilot parks through the 2007 season and beyond. However, a long-term monitoring program can establish relationships between air quality and foliar injury, and can identify trends in foliar injury.

Based on observations and feedback from the five pilot parks, the revised handbook will be completed by the end of summer 2007 and posted at http://www2.nature.nps.gov/air/Permits/ARIS/networks/index.cfm. Staffs at national parks that identify air quality and ozone as a concern will be able to download and implement the assessment protocols it provides. ■

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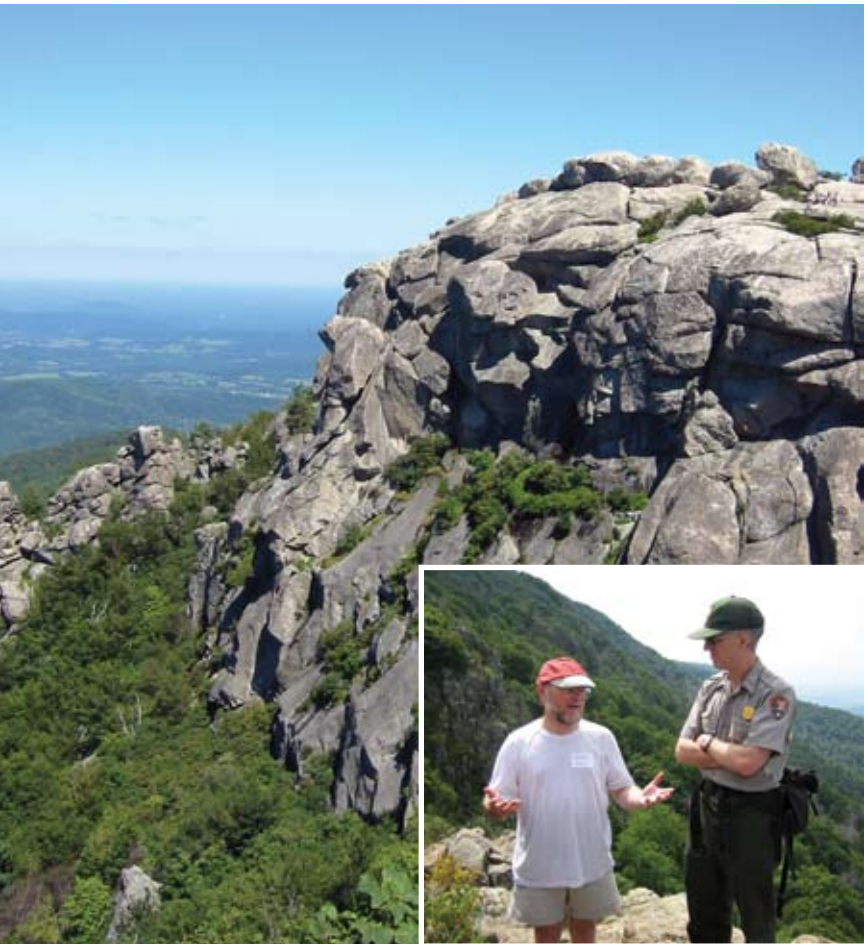
Finding balance: Protecting the visitor experience and rock outcrop natural resources at Shenandoah National Park

By Wendy Cass

ROCK CLIMBERS AND HIKERS FLOCK TO THE coarse granite and rugged topography of Old Rag Mountain at Shenandoah National Park, filling the 200-vehicle parking lot to capacity on fall weekends. Sensitive natural resources also concentrate on Old Rag, including state-listed rare plant species, two globally rare plant communities, and nesting sites for the peregrine falcon (*Falco peregrinus*). Trampling damage to rare plant species and communities is a long-standing problem on the mountain's summit.

Finding ways to protect rare natural resources that occur within popular hiking and rock climbing areas without restricting the visitor experience is an ongoing challenge at the park, located on the crest of the Blue Ridge Mountains of Virginia, and seeing 1.1 million visitors annually. Attempts to redirect visitors to less sensitive areas have met with mixed success and have been plagued by law enforcement difficulties. Closing areas to visitors might be the most desirable solution to protect rare resources. However, this option is incompatible with recreation, unenforceable, and likely to shift impacts to other sensitive sites.



To protect fragile natural resources at certain sites from damage by visitor activities, the Rock Outcrop Management Project has engaged the public. Shenandoah National Park Superintendent Chas Cartwright listens to a visitor's concerns during an on-site field trip to discuss rock outcrop management issues.

The Shenandoah Rock Outcrop Management Project (ROMP) was born of the realization that park staff needed to take a comprehensive approach to managing the combination of visitor use and resource protection of these sensitive areas. The three-year (2005–2007) project, funded by the Natural Resource Preservation Program, is an ongoing example of successful collaboration among National Park Service managers, state and university natural resource experts, and user groups. This large, interdisciplinary project is combining aspects of mapping, resource inventory (zoology, botany, and geology), recreational use and impact assessments, and public education and outreach. It will conclude with the development of a comprehensive rock outcrop management plan for the park.

The majority of ROMP funding has been used to complete natural resource inventories and to assess visitor use and impacts. The resource inventories found that 96% of the 50 ROMP sites had significant natural resources. Botanical findings included nine globally rare plant communities, two of which are endemic to the national park, six previously undescribed lichen species, and 19 state-listed rare plant species. Zoological discoveries included the federally listed endangered Shenandoah salamander (*Plethododon shenandoah*), the state-listed threatened peregrine falcon, the state-listed rare small-footed bat (*Myotis lebii*), and seven state-listed rare invertebrate species. Forty percent of these sites exhibited moderate to severe human impacts in the form of unofficial trails, campsites, rock graffiti, trash, and soil and vegetation damage.

The establishment of frequent, open communication with park user groups is a central component of the Rock Outcrop Management Project. Close attention to this need has built good rapport with user groups, and helped the project avoid the pitfalls of mistrust and negativity that can taint interactions between the public and government.

Close attention to [frequent, open communication] has built good rapport with user groups, and helped the project avoid the pitfalls of mistrust and negativity that can taint interactions between the public and government.

One key strategy was initiating interaction with the public very early in the project planning process. Within the first six months, project coordinator Steve Bair was sending overview information to an e-mail list of organizations and individuals likely to be interested in the project. Shortly thereafter the park held widely advertised public workshops to explain the project objectives, gather people's concerns and suggestions, and answer questions. The feelings of mistrust were palpable at these first meetings. However, interactions began to warm after the workshop summary notes were distributed, and park staff made extensive efforts to follow up on the questions, concerns, and suggestions voiced during the workshop.

On a ROMP-sponsored field trip attended by 35 people, park staff and the public discussed resource protection and visitor concerns. For example, trails associated with climbing activity ran through several rare plant populations. Once on-site, however, all parties agreed that the closure of one climbing route, combined with minor trail relocations and educational signs, was acceptable to all. In another instance, the majority agreed that the mountain's secondary summit, currently accessed by an unofficial trail, could be closed to visitors to protect sensitive vegetation, with only minor effects on the experience of climbers and hikers. The field trip was extremely helpful in identifying possible solutions.

Maintaining constant open communication has not been easy, and interactions have not always been amiable. However, the collaborative approach used in this project has allowed concerns to be voiced and addressed before they might become larger sources of frustration and misunderstanding. After many months the project has finally yielded a mutually trusting relationship between the park and stakeholders. The Shenandoah Rock Outcrop Management Project will conclude in 2007 with the completion of a comprehensive environmental assessment and management plan for rock outcrop areas within the park. These plans will not hold any surprises for stakeholders because they have been involved throughout the development process and understand the logic behind the decisions. ■

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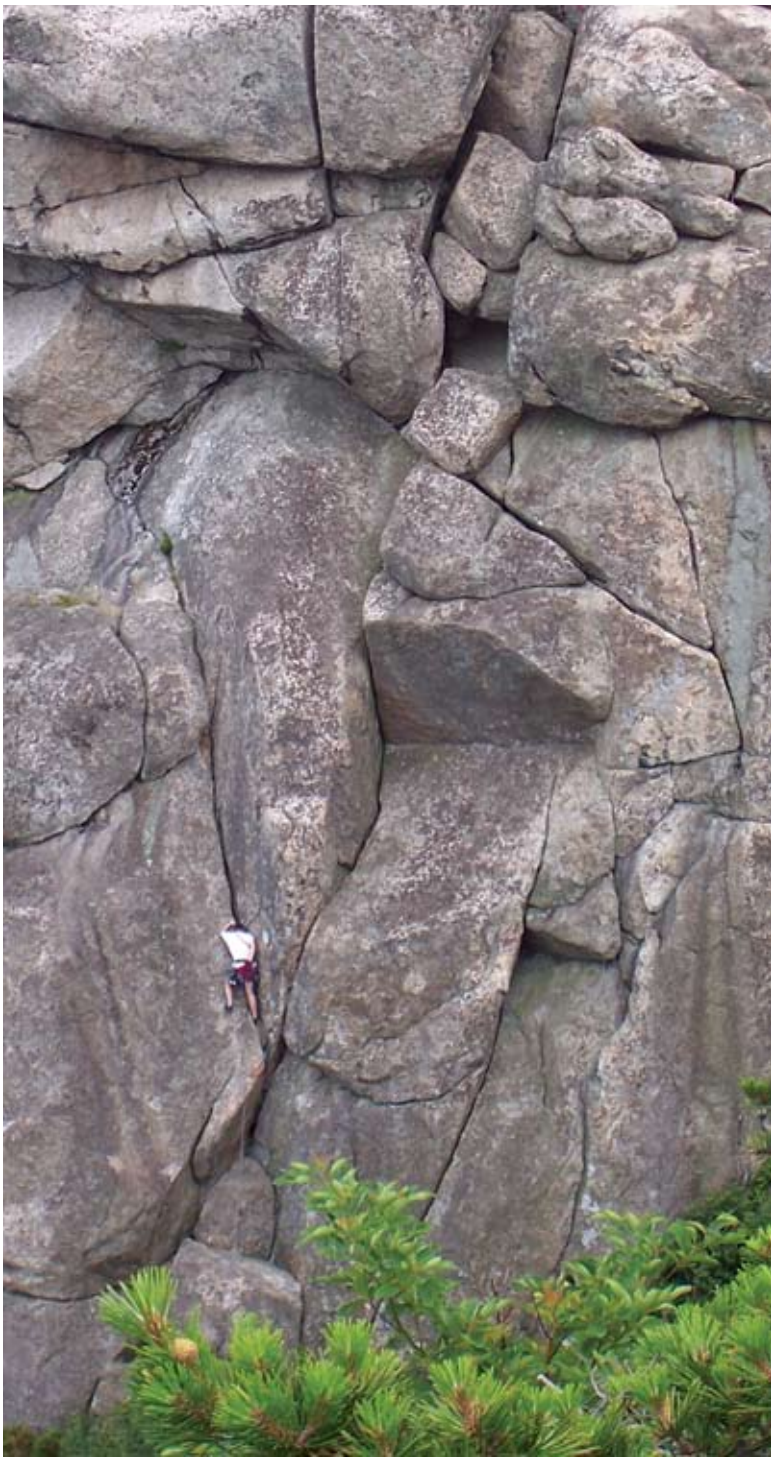


Old Rag Summit tempts climbers to ascend, but the special ecosystem associated with these rocks is threatened by the climbers' activity. A three-year management project has resulted in greater protection of rare plants and animals living on the rock outcrop while preserving use of many popular climbing routes.

Visitor impact mapping monitors the condition and management of Oregon Caves

By Elizabeth Hale

MANAGING VISITOR IMPACTS IS A FREQUENTLY considered factor along heavily traveled corridors on park lands, whether above or below the surface. However, more so than on the surface, visitor impacts in caves tend to be cumulative and difficult or impossible to reverse. A cave is a low-energy environment, where the slow dripping of water builds flowstone and draperies out of calcite, and darkness and limited food sources cause organisms to adapt in ways not observed anywhere else. It is an environment where thousands of high-energy human visits annually can have a profound impact on its aesthetic and ecological integrity.

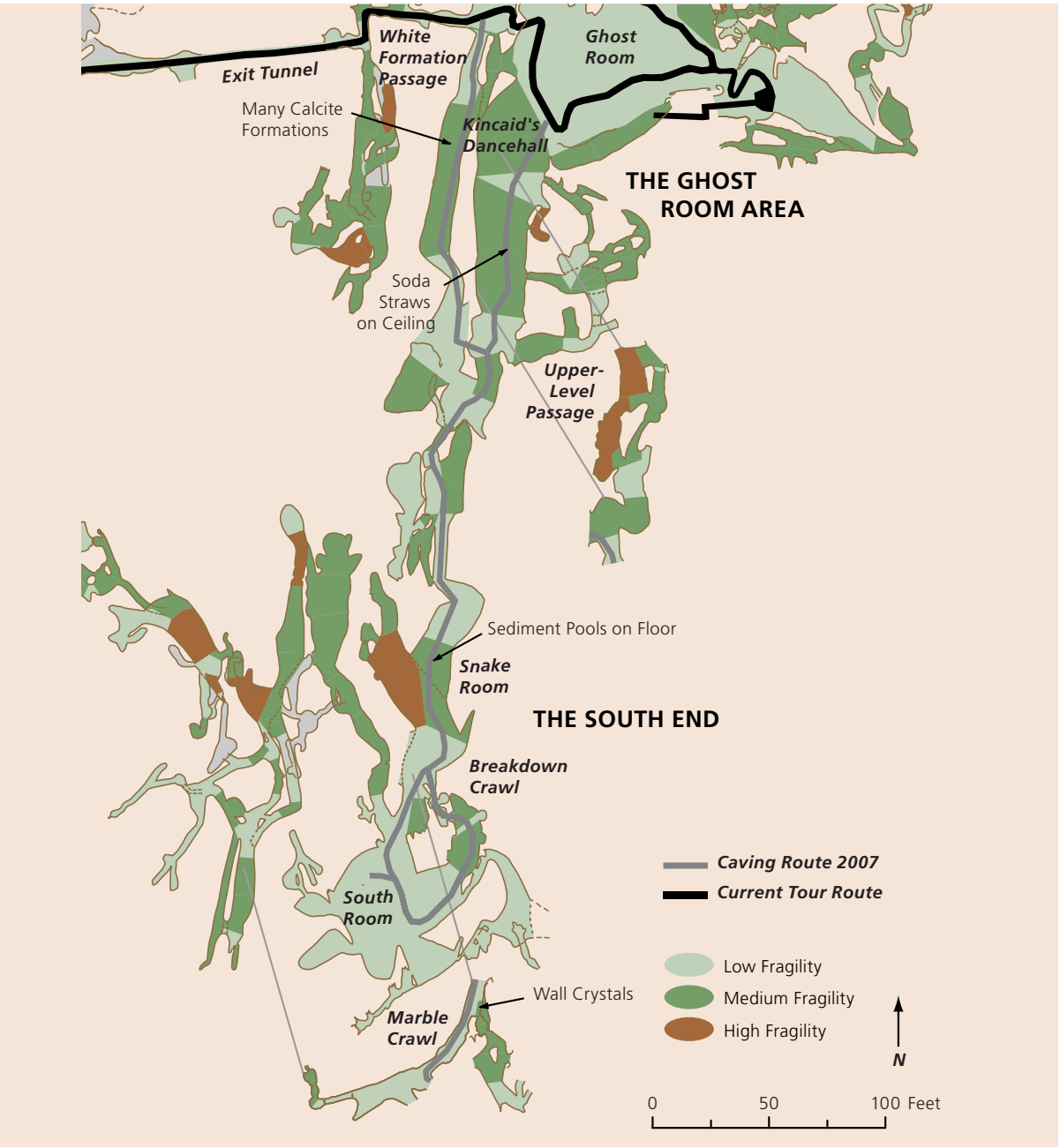
In 2006 a project to comprehensively map visitor impacts with Geographic Information Systems (GIS) at Oregon Caves National Monument gave resource management staff the opportunity to develop new methods for understanding the severity, extent, and nature of impacts on a cave system. Visitor impact mapping (VIM), a concept credited to caver Hans Bodenhamer, is a technique for monitoring a cave's condition with maps of impacted surfaces and damaged or vulnerable features. Over time, "impact maps" reveal how well cave management practices have protected the cave and can guide decisions about cave use. An intensive VIM effort at Oregon Caves, incorporating GIS layers, inventories, assessments, and geographically linked digital photos, is helping park managers find the balance of providing for recreation, research, and education while protecting cave resources.

Oregon Caves has a 0.6-mile (1 km) paved tour route and is visited by about 48,000 people annually. Many visitor impacts in the cave are readily visible along this route: stalactites broken off for souvenirs, flowstone surfaces scratched and scarred from path construction and the resulting rubble, and calcite formations that are darkened or polished from touching. Less obvious are the trace amounts of lint, skin, and hair that each person leaves behind. Organic, human-caused debris, as well as algae growth around tour-path lighting, can serve as food sources for nonnative species. Along the new "off-trail" caving tour, which opened in summer 2007, and in other off-trail passages of the cave, deposits of sediments and animal bones and fossils are vulnerable to disturbance.

Foot traffic increases the bulk density of sediments on the cave floor. This may affect microbial activity and biodiversity, water infiltration rates, and amount of runoff. However, quantifying dramatic visual differences is not as easy as it looks.

The focus of VIM project work was to inventory and quantify visitor impacts in the cave and to establish data sets and methods for monitoring. Prior to this project, related efforts to assess and monitor the cave's condition included establishing fixed-point photomonitoring stations and classifying cave passages according to the hazards they present and their vulnerability to impairment. From summer 2006 through winter 2006–2007, resource management staff revisited the photomonitoring stations to make a new photo set, mapped algae growth around tour lights, and conducted inventory along heavily used passages for the presence and severity of 29 types of impacts. Staff also surveyed and photographed more than 140 bone sites and created a photo inventory of more than 80 features of concern or value. The result of the integration of this fieldwork with preexisting data sets is an expandable geodatabase that contains mapping and monitoring data related to understanding and mitigating visitor impacts.

Park managers will use project data to closely monitor the impact of off-trail caving tours, which will use a part of the cave that has not previously been toured by the public. Baseline data sets, including photos tied to specific locations and dates, the point locations of bone deposits, and an inventory of visible impacts and their severity along the caving route, will be compared with future route conditions to evaluate the impact of off-trail tours. In the meantime the existing data suggest that the impacts most likely to increase from caving tours are polishing of rocky surfaces used for footholds and handholds, sediment compaction on floor surfaces, and hair and lint accumulation. This has led to the recommendation that visitors wear bandanas to secure their hair, and the placement of flags and markers to designate specific paths through the area.



Data collected from the Visitor Impact Mapping project, like this criteria-based fragility assessment of Oregon Caves' passages, help with resource protection planning for the new "off-trail" caving tour. This map shows the vulnerability of Oregon Caves' passages to visitor impact and points out specific fragile features along the caving route, which does not go through any high-fragility passage.

Additionally, hazard-fragility classifications and the knowledge of bone-site locations along the route will pinpoint where guides need to emphasize safe caving techniques to avoid hazards and protect resources.

As part of the VIM project, a sediment compaction assessment and a vandalism inventory (where broken formations are tagged with UV-fluorescent marks to identify if and where new breakage occurs) will be completed in late 2007. Other efforts, such as monitoring total ionic concentrations in trailside pools and fixed-point photomonitoring, are ongoing.

Visitor impact mapping at Oregon Caves strives to protect the cave's nonrenewable resources with a high level of detail and care. A cave, because of its fragile nature, is best treated as a still pool—one where we want to make as few ripples as possible. ■

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EarthCaches at Acadia National Park: Virtual treasure hunts educating visitors on the richness of park resources

By Ginny Reams and Stuart West

Unlike Acadia's virtual EarthCaches, traditional caches typically include a container filled with a logbook and other trinkets and "treasures" that can litter the landscape. Placement of traditional caches may also require participants to leave established trails, which damages vegetation and can harm other natural or cultural resources.

STAFF AT ACADIA NATIONAL Park (Maine) are turning the growing interest in geocaching, a modern-day treasure-hunting activity prohibited in most National Park System units, into a park-sponsored program that educates visitors on the geologic riches awaiting them within park boundaries. In summer 2006, park staff, led by Park Ranger Stuart West and volunteer Mollie Behn, developed a pilot NPS-hosted educational program that emphasizes the unique natural features of the park through virtual "EarthCaches," educational messages that impart knowledge without impacting the environment.

Geocaching is an activity in which participants search for hidden caches using Global Positioning System (GPS) units, and it has become increasingly popular since its creation in 2000. More than 340,000 caches were active worldwide as of December 2006 (Groundspeak 2006). After all, who can resist a treasure hunt? Whose heart doesn't beat a little faster when faced with the adventure and thrill of following a trail littered with obscure clues toward a final reward?

Leaving items behind, however, is one of the problems associated with the physical creation of a traditional geocache. In traditional geocaching, individuals and organizations set up caches and share their location coordinates via an Internet Web site. GPS users then use those coordinates to search for the cache. Caches can take many forms, but all contain a logbook for recording comments. Traditional caches can also contain items purposely left behind by previous visitors (see photo). These items vary from small, inexpensive knickknacks to maps, books, games, or even loose change. Anyone who takes an item (or "treasure") is expected to leave something in its place.

Though rugged, unspoiled natural areas may seem to be desirable spots for hiding—and seeking out—geocaches, their presence in U.S. national parks can be troublesome. Unintentional damage caused by the inappropriate placement of a cache or by participants who develop social trails when they leave established trails to look for a cache can result in serious impacts on a park's natural, historical, and cultural resources. Because federal regulations pertaining to national parks prohibit abandonment of property, disturbance or damage of natural features, and, in some areas, off-trail hiking, most units of the National Park System, including Acadia, do not permit geocaching. In some sites, however, such as national recreation areas, geocaching may be permitted. This disparate treatment of geocaching creates a problem for the geocaching community and a challenge for National Park Service employees who are asked to explain the reasons behind it.

Despite the prohibition against geocaching in Acadia, unauthorized geocaches are often located within national park boundaries. Since 2000, park rangers have found and removed at least 17 physical geocaches from Acadia National Park lands. An additional 21 geocaches are now located on Mount Desert Island outside park boundaries.

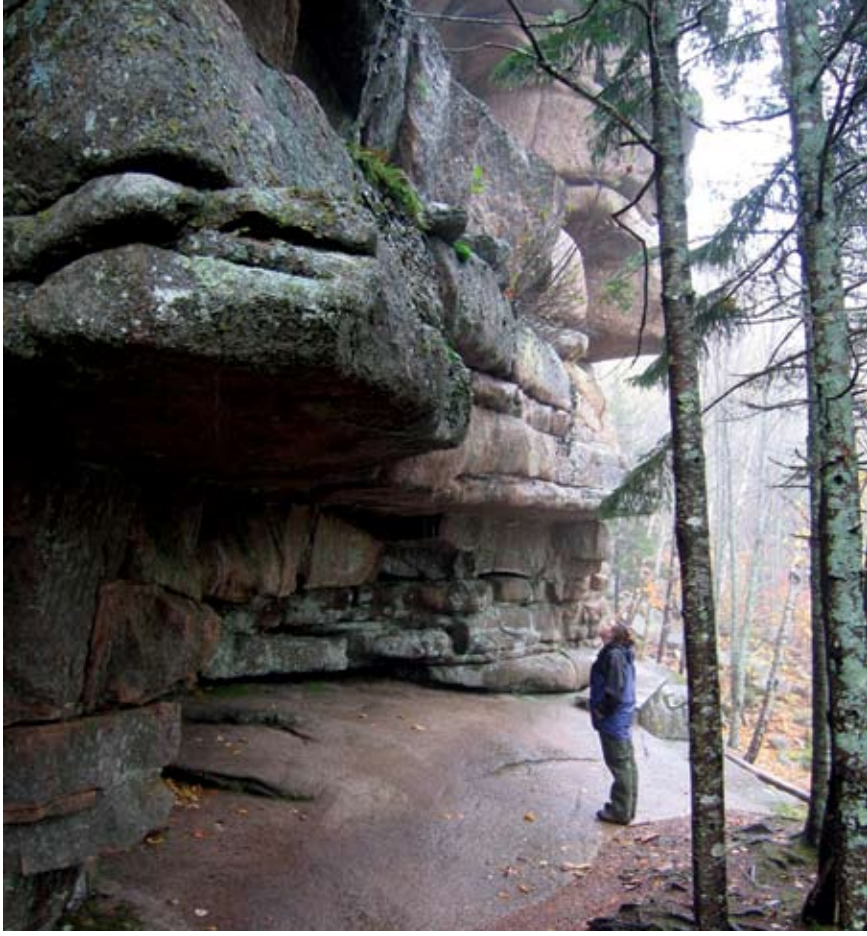
With the increasing popularity of geocaching and related GPS-driven activities as well-established, international pastimes, Acadia National Park staff began looking for a means to protect park resources while providing the geocaching community with an exciting way to enjoy those resources. In consultation with Marcia Keener of the NPS Office of Policy, Geological Society of America (GSA) staff, and local geocachers, Acadia National Park staff settled on the creation of a more environmentally sensitive caching activity based on the GSA's EarthCache concept.

Unlike geocaches, EarthCaches are a type of virtual (nonphysical) cache that teach something about the site—how it was formed geologically, why it is important scientifically, what it can tell us about our planet—without impacting the environment (see photo). There is no physical cache full of objects. With EarthCaches the knowledge gained is the treasure. To ensure appropriate educational content, EarthCaches are judged for suitability by the EarthCache team, which is part of the Geological Society of America. The concept of EarthCaches was developed by Gary Lewis of the

Geological Society of America and Judy Geniac and Bob Higgins of the National Park Service.

The Acadia National Park EarthCache Program includes a series of park-developed "offset" caches—caches that take the seeker to more than one location along the trail toward the treasure. After downloading background information and starting coordinates from the park Web site (http://www.nps.gov/acad/earthcache.htm), participants begin the treasure hunt. At each location, caches offer educational messages about the park's geologic resources and clues to determine location coordinates to subsequent caches. Instead of physical containers, these caches are small, laminated posters hidden from public view. The final cache is a letterbox cache, located inside a park facility, that includes a logbook and a stamp for marking the personal logbook of participants. The lack of traditional physical caches and the park's selection of areas used in the program, including durable surfaces for cache locations, prevent resource damage and enhance visitor safety. The experience is designed to be challenging and informative and to help foster appreciation, support, and protection of Acadia National Park.

The EarthCache Program is being tested by park staff and experienced geocachers as part of its pilot phase and will be available to the public by spring 2007. Because it was developed cooperatively, Acadia's EarthCache Program can meet the needs of a number of different audiences. It appeals to the geocaching community by providing a fun, innovative, and educational way to explore the outdoors using current technology. It allows park staff to meet its resource management, resource and visitor protection, and interpretation objectives. It also offers an alternative to traditional geocache activities across the National Park System. By offering participants a new adventure in the national parks, EarthCache programs like Acadia's provide opportunities for visitors to build vital connections with extraordinary resources. Not a bad outcome for a virtual treasure hunt. ■



Each stop in Acadia's EarthCache Program highlights some of the park's significant geologic resources. (Top) Volunteer Mollie Behn studies a sea cave that today sits well above sea level. (Bottom) A participant studies a sea stack formed by the ocean's erosive power.

Reference

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2 Understanding Park Resource Interactions on an Ecological Basis

To carry out its conservation mission, the National Park Service must understand how the resources in its care function as an ecological whole. Until recently this need for scientific resource knowledge was all but overlooked in park management. Thankfully, over the past few decades and especially over the past 15 years, the National Park Service has built and integrated robust science capabilities into park operations. As a result, park science has embarked on a journey toward a more precise understanding of park resource interactions, enabling more objective and sophisticated management decisions. Among the recent changes is implementation of an inventory program for describing the diversity, abundance, and distribution of natural resources across the National Park System. Now under way in 32 networks of parks, resource monitoring detects change in key indicator resources. Network staffs have begun to determine assessment points or thresholds in declining resource health and formulate new hypotheses to inform management intervention. Studies needed to guide management responses are aimed at understanding stressors, including climate change, the relationships among species and habitats, and many other physical and biological interactions. Data are available for large-scale analyses that will enable us to draw conclusions about park resource trends, with potential for greater understanding of patterns on multipark and even regional scales. The network approach to monitoring design and reporting, which involves multiple parks with similar biogeographic characteristics, is proving efficient. Collaboration is on the rise for sharing stewardship responsibilities and increasing the rigor of science. The following articles suggest that the National Park Service is beginning to understand the complex systems under its care.

"A science of land health needs, first of all, a base datum of normality, a picture of how healthy land maintains itself as an organism." —**Aldo Leopold**

Sixty-one eastern parks coordinate forest monitoring

By Brian R. Mitchell and Matthew R. Marshall

FORESTS, THE DOMINANT ECOSYSTEMS OF THE eastern United States, are intricately tied to the health of our national parks. Consequently, understanding forest health is fundamental to knowing the condition of park resources. Forest monitoring programs are critical to gaining this knowledge and many are in existence today. Unfortunately, these programs often use different definitions and methods, making comparison of their results difficult. Thanks to coordination among a number of national parks and monitoring programs in 2006, some agreement on forest monitoring approaches is emerging, which bodes well for our understanding of forest health.

In the eastern United States, a variety of state, federal, and nongovernmental organizations operate dozens of vegetation monitoring programs. Results have been used to guide conservation, research, and management actions, often at a local scale. Although some effort at alignment among these programs has been made in recent years, most programs operate independently. The lack of coordination has resulted in conflicting terms and definitions, redundant data collection, inconsistent field protocols, and, sometimes, flawed survey designs. A coordinated approach would allow meaningful and valid comparisons among programs and regions and, potentially, significant cost savings.

Several eastern national parks and monitoring networks have joined forces to ensure that their protocols for tracking forest health are compatible with each other and with the USDA Forest Service's Forest Inventory Analysis and Forest Health Monitoring programs. Participants include four National Park Service (NPS) regions, with eight Inventory and Monitoring (I&M) networks, and three prototype parks. Parks within an I&M network have similar environmental characteristics. Prototype parks are select parks where protocols for inventory and monitoring are developed. Sixty-one national parks (23% of the parks in the Inventory and Monitoring Program) are participating. They belong to the Appalachian Highlands, Cumberland Piedmont, Eastern Rivers and Mountains, Great Lakes, Mid-Atlantic, National Capital Region, Northeast Coastal and Barrier, and Northeast Temperate networks; Cape Cod National Seashore (Massachusetts), Great Smoky Mountains National Park (Tennessee and North Carolina), and Shenandoah National Park (Virginia) are also participating as prototypes. The monitoring programs range from those that have been collecting forest data for years (the three prototype parks) to those that began (or will begin) installing monitoring plots in 2006 and 2007.

This monitoring plot at Manassas National Battlefield Park, Virginia, exhibits a healthy forest with good regeneration and an understory of primarily native species, which set it apart from the overbrowsed condition of the rest of the park.

The participating programs had two meetings in 2006 to discuss, evaluate, compare, and standardize their respective monitoring protocols. These meetings have resulted in much closer coordination of protocols among networks and parks, and in particular have resulted in the adoption of similar definitions, and agreement on size classes, that will be compatible across programs. This level of agreement will greatly simplify meta-analysis of monitoring results, and will allow the different programs (which often monitor resources in small park units) to pool results to

This part of the forest at Chesapeake and Ohio Canal National Historical Park near Great Falls, Maryland, has poor tree regeneration and an understory dominated by Japanese stilt grass, an invasive species.

examine broad forest health trends across much of the eastern deciduous forest ecosystem. An additional meeting in January 2007 provided participants with program updates and continued discussions about coordination among programs. Participants expressed interest in the forest ecological integrity scorecard being developed by the State University of New York's College of Environmental Science and Forestry and the Northeast Temperate Network. Future meetings will work on finding common metrics that can be used in the scorecard and adapting the approach for application beyond the Northeast Temperate Network.

In addition, after the January 2007 meeting, the National Capital Region Network gathered forest plot data from nearly 2,500 plots in 50 national parks of the participating networks in order to examine the incidence of exotic plant species. The data came from long-term forest monitoring plots established by the networks and parks as well as from plots established by the NPS Vegetation Mapping Program, and the analysis served to demonstrate the potential for meaningful cooperation. This broad survey found that 48% of plots had no exotic species; however, on average there were 2 exotic species per plot and a mean of 24 exotic plant species per park. The most common of the 290 exotic species detected in these parks were Japanese honeysuckle (*Lonicera japonica*), Japanese stilt grass (*Microstegium vimineum*), and multiflora rose (*Rosa multiflora*); each of these plants was found in more than 300 plots. This is the first of what network participants hope will be many analyses that will examine the health of forest resources in eastern parks.

The participants in this series of coordinated forest monitoring meetings feel that the interactions have been valuable, and they plan to continue this collaboration. The existing and pilot monitoring programs have benefited from additional peer review and assistance that have strengthened the scientific rigor of their programs. Networks in the planning stages of their monitoring efforts are experiencing considerable cost savings in protocol development by using existing protocols that incorporate methods they helped to develop. Future benefits may include cost savings in data analysis and reporting and in sharing field crews (and crew training) between programs. As more of the eastern networks implement long-term monitoring in the coming years, network participants anticipate many additional rewards from our collaborative forest monitoring efforts. ■

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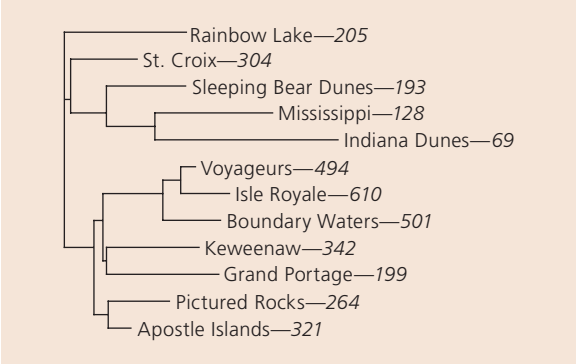
Twenty-four years of Great Lakes lichen studies provide park biomonitoring baselines

By James P. Bennett

FOR THE PAST 24 YEARS, BIOLOGISTS HAVE studied lichens in the Great Lakes national park units in considerable detail (see map), including floras and chemical element surveys, for biodiversity and air quality assessments. They have studied lichens because they are sentinel species indicating ecosystem health, and because they are excellent biomonitoring and bio-indicator species of air quality. These studies have been funded by individual parks, the NPS Air Resources Division, and the U.S. Geological Survey.

It is well-known that lichen diversity increases with latitude in this region, and this is seen in the numbers of species in the parks (see dendrogram). The five areas in the top group are located south of 46°N latitude, are either associated with rivers or have very little rock substrate (which is usually rich in lichens), and average 180 species per park. The seven areas in the bottom group (five are in the Lake Superior basin) are north of 46°N and average 390 species per park, more than twice as many as in the other group.

A species that grows exclusively on rocks, the elegant sunburst lichen (*Xanthoria elegans*) is found in 56 U.S. national parks. In the Great Lakes area it has been documented at Apostle Islands, Isle Royale, Keweenaw, Saint Croix, and Voyageurs as part of ongoing lichen studies.

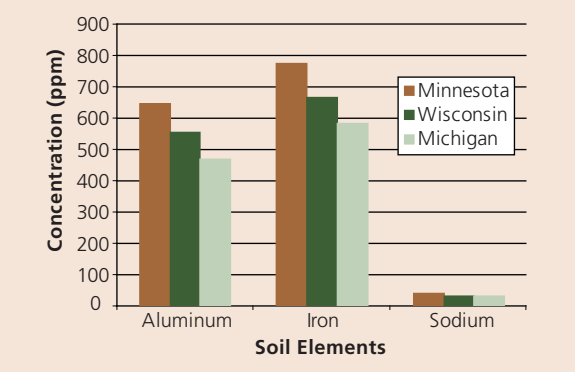


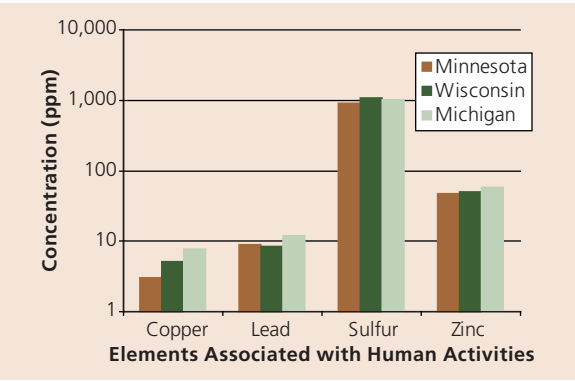
The dendrogram shows the relationships among the park/forest areas based on the diversity of lichen species present in each area. The sum of the lengths of all horizontal lines between any park/forest pair is a measure of how similar or dissimilar the areas are based on lichen species. The number of lichen species inventoried in each park/forest follows the area's name.

Lichen study areas in the Great Lakes region.

Indiana Dunes National Lakeshore has the fewest lichen species, is the most southern and most heavily influenced by human activities, and is the least similar to any other park. However, along with Apostle Islands National Lakeshore and Grand Portage National Monument, it also has two unique species. The relatively high number of single occurrences of species of lichens of all these areas is probably greater than that of the vascular plants, and they deserve consideration for special management and protection.

Investigators have analyzed more than 35,000 elemental chemistry records from lichens of 10 of these areas. Using the data for the four most common lichen





Mean concentration of chemical elements in four common lichen species sampled in 10 national park/forest areas, by state, 1982–2006.

species, they have found that some chemical elements increase and some decrease in parks from west to east (see graphs).

The soil elements aluminum, iron, and sodium decrease from west to east, probably because of increasing distance from blowing dust of the Great Plains. However, elements associated with human activities—copper, lead, sulfur, and zinc—increase from west to east with increasing proximity to eastern population centers. Investigators have also examined chemical patterns through time and have found, for example, that lead concentrations in lichens, which averaged from 17 to 23 parts per million (ppm) in the early 1980s, have decreased significantly to levels below 6 ppm in the mid-2000s in the three-state area.

In addition, the studies have identified elemental differences among parks and species using discriminant analyses. Differences among species appear to be greater than differences among parks. Biomonitoring of air quality in parks must therefore be done with certain species to control the precision and accuracy of data over time and space.

The relatively high number of single occurrences of species of lichens of all these areas is probably greater than that of the vascular plants, and they deserve … special management and protection.

Both the elemental data and the species presence data are now available on Web sites of the U.S. Geological Survey: *NPElement* at www.nwhc.usgs.gov/our_research/np_element.jsp (more than 70,330 data points) and *NPLichen* (more than 29,000 data points) at http://www.ies.wisc.edu/nplichen/.

Investigators continue their detailed analyses of many spatial and temporal patterns in this region. Their greatest challenge is interpreting results for the region as a whole. Parks are not distributed geographically in such a way that strong regional inferences can be made, but conclusions about the areas themselves will be possible. The lichen richness across these areas is greater than that of any of the states they are in, and the high degree of single occurrences of certain lichen species among them suggests that their special area protection has been responsible for this. Investigators hope to emphasize this in the future so that area managers will have more information to maintain and improve protection practices. Finally, the establishment of biomonitoring baselines for these areas has been enhanced by being able to compare individual areas with others, thus improving spatial and temporal trends results and interpretation. ■

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Aquatic insects inventoried in Appalachian Highlands and Cumberland Piedmont network parks

By Jason Robinson, Charles R. Parker, and Nathan J. Sanders

THE SOUTHEASTERN UNITED STATES HAS THE highest biodiversity of aquatic insect species of any region in North America. Approximately 1,400 (40% of all) North American aquatic insect species occur in the Southeast. Data from a variety of sources (the All Taxa Biodiversity Inventory in Great Smoky Mountains National Park [North Carolina and Tennessee], monitoring programs in Big South Fork National River and Recreation Area [Tennessee] and Mammoth Cave National Park [Kentucky], and academic studies in Little River Canyon National Preserve [Alabama] and Shiloh National Military Park [Tennessee]) suggest that the national parks in the region harbor a significant subset of these southeastern aquatic insect species. In 2005, scientists and university researchers began a three-year study to inventory the aquatic insect fauna of the 17 parks of the Appalachian Highlands and Cumberland Piedmont monitoring networks. Funded by the USGS–Natural Resource Preservation Program, the project's 2006–2007 focus is on completing the fieldwork to fill in spatial and temporal gaps in coverage throughout the parks, and on sampling unique habitats and taxa of particular interest.

To design this study researchers contacted the National Park Service (NPS) for approval and assistance. Then, relying on the NPS "networks" for permits, Geographic Information Systems data, suggestions on sampling locations, and overall logistics, they began the exhaustive inventory project. Drawing upon combined resources and technical staff, national parks across the nation have formed regional networks to better monitor and inventory ecosystems and identify critical indicators of ecological health, called vital signs. The goals of this study are to determine the significance of the national parks of the Appalachian Highlands and Cumberland Piedmont networks as reserves for aquatic insects, and to make recommendations to the management of each park for the long-term conservation of their fauna. Specific objectives include conducting an inventory of the EPTO (Ephemeroptera, mayflies; Plecoptera, stoneflies; Trichoptera, caddisflies; and Odonata, dragonflies and damselflies) fauna of each park and providing the parks with assessments of their aquatic insect fauna. Assessments will include national and state conservation status for each species, perceived threats to the habitats where species of concern are found, and the relationship of park fauna to southeastern fauna as a whole. Other objectives include providing parks with information on the identification, distribution, life history, and biology of each aquatic species; contributing data to the NPS inventory and monitoring databases; and testing ecological and evolutionary hypotheses about the development and maintenance of this amazing diversity.

In 2006, researchers made more than 200 collections in 17 network parks. In each park they discovered species not previously known in that park. In at least 7 parks, they discovered species new to science. Researchers also discovered several species that are endemic, rare, and poorly known. In addition they demonstrated that some species thought to have highly restricted distributions are, in fact, much more widely distributed. The 4 parks of the Appalachian Highlands Network have more species, genera, and families of aquatic insects than the 13 parks of the Cumberland Piedmont Network. Of the 233 species collected in 2006, however, only 68 (29%) are shared between the networks. These findings have a biological importance independent of the management issues underlying the study and contribute to a better understanding of evolutionary, ecological, and biogeographic relationships among aquatic organisms. The findings will, in turn, provide information on practical management issues.

A regional assessment of threats to aquatic biodiversity is impossible until an inventory of these systems is performed. Since a complete inventory is impractical at the regional scale, this study provides a preliminary analysis of

Researcher Jason Robinson sets up an ultraviolet light trap along South Knob Creek at Abraham Lincoln Birthplace National Historic Site in Kentucky. A photocell turns the light on when the sun sets and off when the sun rises, allowing unattended operation.

A larva of a caddisfly in the genus *Polycentropus* (Trichoptera: Polycentropodidae) collected in North Carolina on the Blue Ridge Parkway. Larvae construct a loose, disorganized web of silk and use it to capture prey, much in the manner of terrestrial spiders.

Rodney Martinez, a biologist with Cumberland Gap National Historical Park (Kentucky, Tennessee, and Virginia), examines insects collected in the park.

In 2006, researchers made more than 200 collections in 17 network parks. In each park they discovered species not previously known in that park. In at least 7 parks, they discovered species new to science.

regional biodiversity conservation potential in national parks. If habitat degradation and fragmentation continue at current rates outside of the parks, researchers will at least have described the aquatic insect biodiversity now present in these national parks.

The discovery of rare and endemic taxa raises more questions, particularly concerning the amount of effort required to completely inventory a park. Fortunately there is an ever-increasing array of statistical approaches to address the extent of undersampling. Although these tools can provide an estimate of species that might be captured if a park were completely sampled, they do not tell managers which species have yet to be detected. Only exhaustive collecting can accomplish this goal.

As a whole, this project has important conservation, management, ecological, and evolutionary implications. First, researchers can continue to locate rare species and those that are new to science. This information will clearly be important for management decisions within these national parks. Second, the work can pose new questions regarding the ecological factors that limit the number of species found at any one place at any one time, an age-old issue that has been little explored in aquatic insects at this spatial scale. Finally, with the advent of modern molecular tools, this extensive inventory and monitoring research can aid in untangling the complex evolutionary history of aquatic insect species in the southeastern United States. ■

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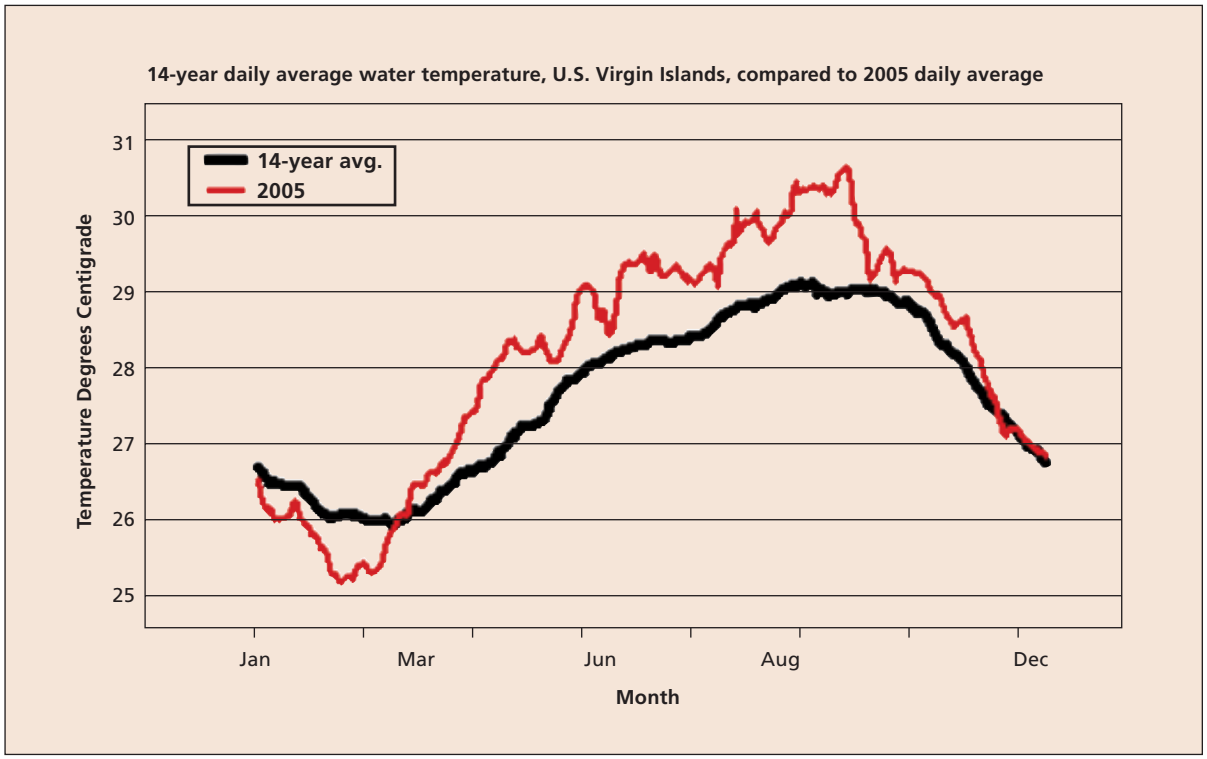
Coral reef monitoring offers case study for identifying monitoring assessment points

By Matt Patterson

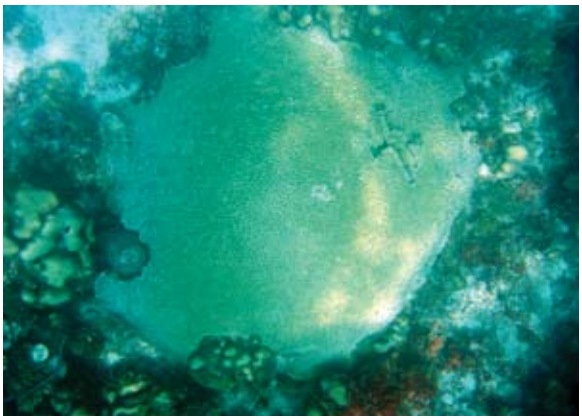
NATIONAL PARKS ARE PLACES OF SPECTACULAR beauty, but beauty is not a sufficient indication of the condition of park resources. Park managers need accurate information about the plants, animals, and natural systems in their care in order to make sound management decisions and undertake adaptive management activities to respond to adverse changes. For this reason the National Park Service's (NPS) Vital Signs Monitoring Program organizes approximately 270 park units into 32 monitoring networks to conduct long-term monitoring for key indicators of ecosystem health, or vital signs. The NPS Vital Signs Monitoring Program is grappling with identifying assessment points for each vital sign. Assessment points establish benchmarks that are used to alert park managers to changes in resource conditions that may suggest the need for different management prescriptions. In 2005 and 2006, changes in ocean temperatures off the U.S. Virgin Islands affected coral reefs in two national park units and provided NPS scientists a case study for identifying an assessment point for coral reef monitoring.

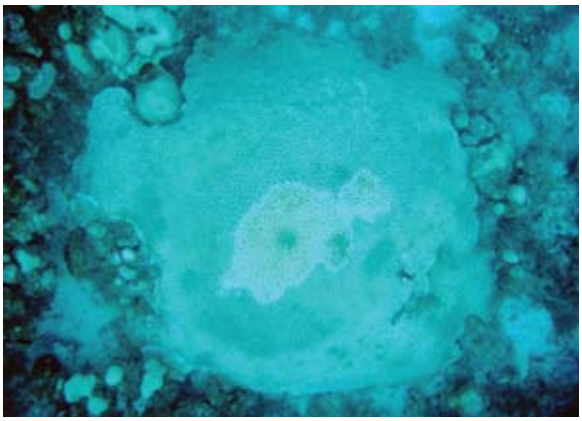
In 2005 and 2006 the South Florida/Caribbean Inventory and Monitoring Network faced an unprecedented increase in oceanic water temperatures; over this period water temperatures exceeded the previous 14-year average in the U.S. Virgin Islands. These higher temperatures were driven primarily by 2005 weather patterns that caused tropical storms to miss the U.S. Virgin Islands. Without storm-induced cloud cover and high winds to mix the ocean, water temperatures rose. This elevation led network staff to increase monitoring of coral reef resources at Virgin Islands National Park and Buck Island Reef National Monument in order to detect the temperature-induced stress responses of the coral reef community.

As water temperatures rose from April through September 2005, monitoring teams visited a subset of high, stony coral reef sites every few months to track the extent of coral bleaching. Under normal conditions, scientists would visit these sites annually, but in 2005 they were alerted to the need for more frequent monitoring



Bleaching occurs when the coral animals experience a 2- to 3-degree Centigrade increase in water temperature that is sustained for days to weeks. As water temperature rose in 2005, network staff monitored transects at Virgin Islands National Park and Buck Island Reef National Monument more frequently, tracking the progression of bleaching to an eventual 90% of stony corals along the transects.





Over many months, divers documented a decline in the condition of stony corals, including this large brain coral (*Colpophyllia natans*), pictured here at Tektite reef, from healthy in August 2005 (top) to bleached in September 2005 (middle). In December 2005 this coral head began to recover from bleaching, but disease, visible as the bright white skeleton (bottom), attacked the top of the head.

as the result of analyzing historical mean water temperatures in U.S. Virgin Islands waters and detecting significant increases. Monitoring network staff understood that with higher seawater temperatures, coral bleaching, or the discharge of the coral animal's symbiotic plant cells, or zooxanthellae, might reduce the coral's ability to survive because of decreased internal food production. In this case an increase in water temperature was the assessment point that resulted in closer evaluation of coral reef resources.

Assessment points could become important management tools for alerting park managers to changes that require intervention on their part to preserve park resources.

More frequent monitoring allowed network staff to document a coral bleaching event that affected more than 90% of the stony corals. It also revealed that recovery and disease transmission rates varied by coral species and colony shape. Staff documented the widespread presence of coral disease, which unfortunately ravaged the already weakened corals, and the subsequent mortality of more than 50% of the live coral cover at the monitored reef sites. Management practices that could alleviate this loss throughout the two park units are not available yet.

Assessment points may require different management actions and need to be addressed early in park planning. For example, some assessment points may trigger an administrative action (e.g., no new permits issued for backcountry access), and others may require outreach to educate people in the region to help mitigate an impact (e.g., water conservation during a drought, or no ground fires permitted during high fire danger). Many other assessment points, including increased water temperatures in the U.S. Virgin Islands, may call for expanded monitoring, which could include examining variables that may help to better understand the problem, more frequent monitoring to ensure documentation of a highly dynamic event, and broader spatial-scale monitoring to document spread rates or the extent of the problem. Any management response may require lengthy public review, so management should consider how to address regulatory compliance requirements when changes in management activities are dictated by crisis situations.

Developing assessment points without a complete understanding of the natural variability of vital signs necessitates concerted effort. Science and the expertise of NPS professionals help determine when increased monitoring is necessary. As the National Park Service continues to gain experience in monitoring, assessment points could become important management tools for alerting park managers to changes that require intervention on their part to preserve park resources. ■

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Understanding hydrologic links between "river prairies" and other threatened riparian resources of the Cumberland Plateau

By Nora Murdock, Jim Hughes, and Robert Emmott

RANKED AS GLOBALLY IMPERILED BY THE NATURE Conservancy, "river scour prairies"—a unique riparian vegetation type endemic to the Cumberland Plateau of Tennessee and Kentucky—occur on open, flood-scoured exposures of bedrock, cobble, and gravel along large rivers in the Cumberland River watershed. Also called Cumberlandian cobble bars, fewer than 500 acres (200 ha) of this habitat type remain in existence; the best examples are at Big South Fork National River and Recreation Area and Obed Wild and Scenic River.

Typically thick with prairie grasses and flowering herbs, river prairies share many characteristics with the tallgrass prairies of the American Midwest. Whereas fire is the dynamic force sustaining midwestern prairies, in the bottom of the deep river gorges of the Cumberland Plateau the ecological driver is water. Raging floods wash over these habitats on multiple occasions each year, scouring out species that are not adapted to disturbance, including most trees and other woody species. Grasses, herbs, and some low shrubs thrive under these punishing conditions. Several extremely rare plants, some that grow nowhere else, also flourish in these riparian prairies. In addition, two federally listed species, Cumberland rosemary (*Conradina verticillata*) and Virginia spirea (*Spiraea virginiana*), and several dozen other globally or regionally rare plants grow here.

Alternating layers of Pennsylvanian-age sandstones and shales dominate the surface geology on the Cumberland Plateau. These rocks have very low permeability, so rainfall penetration into the subsurface is limited, especially in areas of steep topography. Consequently streamflow responds rapidly to storm events. In the steep-walled gorges of Big South Fork and Obed, base flows following storms can increase from 100 cubic feet per second (2.8 m^3/s) to 6,000 cubic feet per second (170 m^3/s) in a matter of hours. This rapid increase in water volume and velocity produces pronounced scouring of the streambed and associated riparian areas. These powerful floods, which flush nutrients and sediments through substrates occupied by mussels and other aquatic fauna sensitive to siltation, are essential for the survival and renewal of the cobble bars and the associated aquatic community.

The hydrologic forces that create the upland portions of the cobble bars also sustain prime underwater habitat for a diverse freshwater mussel community. As one of the best and last remaining refuges for freshwater mussels in the Cumberland River watershed—an 18,000-square-mile (46,620 sq km) region that stretches from the western slope of the Appalachian Mountains to the mouth of the Ohio River—the Big South Fork of the Cumberland River provides habitat for 26 mussel species, including 7 that are federally endangered or threatened. Freshwater mussels are essentially sedentary creatures that feed by filtering nutrients from the water column; they are extremely vulnerable to changes in flow and water quality.

Highly resistant sandstone cliffs, rising 500 feet (150 m) above the floodplain, flank the rivers of the Cumberland Plateau. In these steep-walled gorges, heavy rainfall can drastically raise river flow rates within hours of a storm. Resulting floods are crucial to the long-term survival of the rare, prairielike, cobble bar communities along the rivers' edges.

(Top) NPS staff and cooperators sample freshwater mussels at Big South Fork National River and Recreation Area, one of the last refuges for many rare mussel species. Although 26 species presently inhabit these waters, in the early part of the 20th century more than twice that number lived in the river. The best mussel beds are frequently adjacent to cobble bars.

(Bottom) Appalachian Highlands Network cooperators and staff monitor vegetation of river prairies. The best examples of this globally imperiled habitat are within Big South Fork National River and Recreation Area and Obed Wild and Scenic River.

The extraordinary aquatic systems of the Obed and Big South Fork, thought to have been decimated by unregulated pollution and mining in the early to mid-1900s, are showing encouraging signs of resilience. Significant improvements in water quality and the associated recovery of some aquatic fauna have occurred over the last 30–40 years since establishment of these National Park System areas. These habitats are responding to reclamation of abandoned mines and reduction in active mining within the Cumberland River watershed. Based on retrospective analyses of water quality data conducted by the Appalachian Highlands Network and U.S. Geological Survey, water quality trends in these two river parks appear encouraging. Also, results of recently completed fish inventories, compared with

Powerful floods … are essential for the survival and renewal of the cobble bars and the associated aquatic community.

legacy data from fish surveys conducted 25 and 40 years ago, reveal dramatic increases in fish diversity.

Changes in river flow regimes due to upstream water withdrawals and water pollution threaten the continued survival of cobble bar and aquatic communities. The Big South Fork watershed is the site of the majority of past and present coal mining in Tennessee. Acidic drainage from abandoned mines, and contaminants and siltation (including coal particulates) associated with current mining, affect water quality. Moreover, with rising coal prices, companies are proposing new areas for mining, including 53,000 acres (21,450 ha) in the headwaters of the Big South Fork watershed. Oil and gas wells, water withdrawals for municipal and industrial use, and erosion-related sedimentation as a result of soil-disturbing activities, such as development in and adjacent to National Park System lands, also affect water quality and quantity.

In order to detect abnormalities in succession patterns and species composition resulting from hydrologic changes, in 2005 the Appalachian Highlands Network began monitoring vegetation structure and composition on the cobble bars, as well as population trends of selected endemic rare plants. Network investigators are also monitoring river flow rates and water quality in the Big South Fork of the Cumberland River, the Obed River, and their major tributaries. In 2007, network staff initiated monitoring of freshwater mussels and rare fish in order to detect population trends and changes in distribution. The Big South Fork and Obed rivers are strongholds for two federally listed fish species: the spotfin chub (*Erimonax monachus*) and the duskytail darter (*Etheostoma percnurum*). Continued monitoring is essential to ensure that adverse alterations to hydrology and water quality do not reverse trends in recovery of these unique riparian resources. ■

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Historical photos and modern sampling provide insights into climate-related vegetation changes in central Alaska

By Carl Roland

THE VAST LANDSCAPES OF INTERIOR ALASKA ARE changing: large glaciers are melting and rapidly receding up valleys, ancient permafrost is degrading and turning frozen soils into soupy gelatin, woody vegetation is spreading dramatically into open areas, and boreal ponds and wetlands are shrinking. Climate data for interior Alaska show a pronounced warming trend over the past several decades. A growing scientific consensus suggests that a tide of relative warmth is stimulating many of the changes in Alaska's ecosystems. Yet the ultimate trajectory and outcome are unknown. What is almost certain, however, is that these changes will have profound consequences for all life in the Far North.

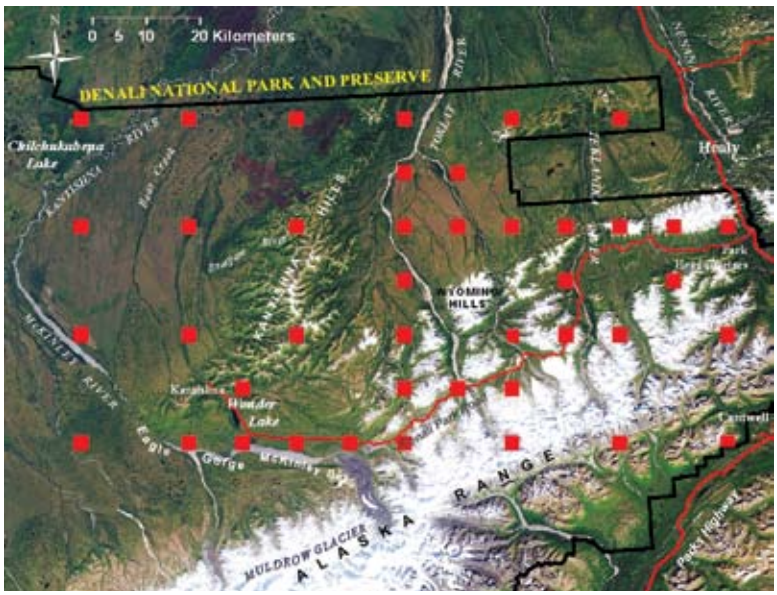
In 2005 the Central Alaska Network received a serendipitous gift of several hundred 35 mm slides, photographed from the backseat of a two-seater airplane in 1976. The donor, Dr. Fred Dean (professor of wildlife biology at the University of Alaska, Fairbanks), and his graduate student, Debbie Heebner, used these photographs to help produce the first land-cover map of Denali National Park. Central Alaska Network staff scanned the slides at high resolution, entered the locations of the photos into a Geographic Information System, and printed hard copies of the slides along with location maps. Then, from a helicopter, the original photographs were repeated as closely as possible. Now examined and analyzed, these photo pairs are a treasure trove of information about visible vegetation changes over the last 30 years.

The magnitude of the observed changes in many of these photo pairs was surprising. The primary types of changes were (1) expansion of spruce into formerly treeless areas, (2) invasion of open wetland areas by woody vegetation, and (3) widespread colonization of formerly open floodplains and terraces by vegetation. In many cases these changes appear directional; that is, they represent a qualitative shift in the landscape mosaic, not simply a shift in vegetation due to succession.

The repeat photo pairs provide dramatic visual evidence of recent vegetation changes. Understanding and responding to these changes requires more rigorous and detailed information. To gather the necessary data, the Central Alaska Network is implementing intensive, landscape-scale monitoring of vegetation across the three parks in the network. Monitoring according to this design began in Denali National Park and Preserve in 2001, in Yukon-Charley Rivers National Preserve in 2006, and in Wrangell–St. Elias National Park and Preserve in 2007. These units comprise 21.7 million acres (8.8 million ha), or 25% of the land area of the U.S. National Park System. The goals of this program are to detect and quantify vegetation changes like those captured anecdotally by repeat photography, and

From 1976 (top) to 2005 (bottom), white spruce trees (*Picea glauca*) colonized a subalpine terrace along the upper Savage River in Denali National Park and Preserve. This photo pair highlights an example of the ongoing replacement, presumably permanent, of one vegetation community by another. Over the past 30 years many such examples appear to have impacted park landscapes.

The rapid invasion of trees and shrubs in this area of open sedge meadow had begun by 1976 (top) but was nearly complete by 2005 (bottom). This wetland, near Corner Lake in the northern lowlands of Denali National Park, had likely supported only open sedge meadow for centuries before the recent invasion by woody plants.



(Above) The vegetation monitoring program for the Central Alaska Network uses a two-stage systematic grid design wherein mini-grids (red squares), consisting of 25 (200 sq m [2,153 sq ft]) sample plots arranged in a grid pattern of five rows of five plots spaced 500 m (1,640 ft) apart, are themselves located on a macro-grid of points spaced 10 km (6.2 mi) or 20 km (12.4 mi) across the park landscape. Investigators record a full suite of physical and biological characteristics at each sample plot.

The repeat photo pairs provide dramatic visual evidence of recent vegetation changes.

to document the dimensions and ecological consequences of these changes using reproducible, statistically rigorous protocols.

The Central Alaska Network has established a sampling design based upon a multistage systematic grid for detecting changes at individual sample plots and across park landscapes. At each plot, network ecologists measured and recorded the types and abundances of vascular plants, mosses, and lichens; dimensions and locations of all trees; and physical attributes, including those from soil samples. Network staff also collected cores from trees at the perimeter of the permanent plots and marked the center of each plot with a monument and mapping-grade Global Positioning System point. Subsequent sampling, to be conducted every seven years, will allow detection of trends in the vegetation cover at multiple nested spatial scales.

With nearly 500 permanent vegetation plots installed to date in Denali National Park and Preserve, network ecologists are already learning a great deal about vegetation-landscape relationships from these data. This work has revealed new information regarding the distribution and diversity of vascular plants across the landscape. For instance, across all spatial scales, the average species richness of plant communities increased dramatically with increasing elevation into the high alpine zone of the park.

Alpine areas also supported the greatest diversity of rare and endemic plants. The data offer an early warning of potential threats to plant conservation: with continued warming, woody vegetation will increasingly invade alpine tundra, thereby displacing these highly diverse plant communities. These data are a single strand in a multifaceted monitoring program that should allow detection, understanding, and management of dramatically changing landscapes in interior Alaska. ■

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Understanding biological diversity of nunataks in southwestern Alaska

By Amy E. Miller

NUNATAKS ARE EXPOSED MOUNTAIN RIDGES OR peaks encircled by glaciers. In Alaska these features occur primarily in the ice-covered areas surrounding the northern Gulf of Alaska. As islands in a sea of ice, nunataks are of interest to biologists because of their geographic isolation and their potential to support species that may have survived the Last Glacial Maximum, approximately 20,000 years ago. In addition to harboring regionally or globally rare species, these high-elevation nunatak communities may be sensitive to fluctuations in climate. As a result, they may serve as early indicators of environmental change. For these reasons the Southwest Alaska Network selected nunataks as a vital sign for monitoring.

Glaciers are an icon of the Southwest Alaska Network, which includes Kenai Fjords National Park, Lake Clark National Park and Preserve, Katmai National Park and Preserve, Aniakchak National Monument and Preserve, and Alagnak Wild River. According to a study by USGS geologist Bruce Molnia (*Global and Planetary Change* 56 (2007):23–56), from the late 19th to early 21st century all 11 mountain ranges and three islands that currently support glaciers in Alaska have experienced significant glacier retreat, thinning, or stagnation, especially at lower elevations. Whether reductions in ice cover are occurring at higher elevations and leading to changes in community composition on nunataks is uncertain.

Nunataks, such as this site on the northern Harding Icefield in Kenai Fjords National Park, are of ecological interest because of their geographic isolation and potential to support species that may have survived the Last Glacial Maximum.

A site adjacent to Tuxedni Glacier in Lake Clark National Park and Preserve serves as a long-term monitoring plot for the Southwest Alaska Network. Staff, including ecologist Amy Miller (shown here), and cooperators conducted a vascular plant inventory of this and 10 other nunatak sites in 2005.

The monitoring of nunatak communities may increase scientists' understanding of how once-isolated populations of rare plants respond as nunataks increase in size or become contiguous with larger ice-free regions.

In order to document the baseline condition of nunatak communities, the Southwest Alaska Network, in cooperation with the Alaska Natural Heritage Program, conducted a vascular plant inventory on 11 nunataks in Kenai Fjords National Park and Lake Clark National Park and Preserve in 2005. An unusually high number of species, including seven species of conservation concern, characterized 2 of the 11 sites. Though widespread in western North America, several of these rare taxa are known from very few sites within the state. Although these plants are not in danger of extinction globally, they are of critical conservation concern in Alaska because they often occur at the edge of their range or are otherwise genetically isolated. One such species, Lemmon's rockcress (*Arabis lemmonii*), ranges from British Columbia to Alaska and east to Colorado, but is known from only a few locations in Alaska and the Yukon. Botanists identified this plant at Lake Clark National Park approximately 345 miles (555 km) from the nearest known collection site in Wrangell–St. Elias National Park and Preserve. Six of the seven rare species, including Lemmon's rockcress, occur predominantly on old, unglaciated terrain in Alaska, suggesting that these nunatak sites may support a relict flora from the Last Glacial Maximum.

In addition to inventorying the vascular flora, Southwest Alaska Network staff established long-term monitoring plots at each nunatak site to document changes, if any, in the structure and composition of these plant communities over time. Investigators will revisit these sites every 5 years for the next 10–15 years, and every 10 years thereafter. During the initial inventory, staff and cooperators observed mountain goats (*Oreamnos americanus*) and smaller mammals, for example hoary marmots (*Marmota caligata*) and voles (*Microtus* spp.), at several of the nunataks; the movement of the larger mammals, along with that of birds, likely aids in seed dispersal. Although most sites supported alpine communities that are characteristic of the region, at least one site in Kenai Fjords appeared to be transitioning from an alpine snowfield community to a more temperate, low-elevation coastal community, suggesting a decrease in snow cover or an increase in the length of the growing season. Another site, at Lake Clark, lacked the rich lichen community found at many other sites, as ash fall from the 1989–1990 eruption of Mount Redoubt had impacted this site.

Lemmon's rockcress (*Arabis lemmonii*) is a rare member of the mustard family. This species, which investigators found on a nunatak in Lake Clark National Park and Preserve, is known from only a few locations in Alaska and the Yukon.

In addition to floristic studies in these high-elevation areas, network staff is developing an array of weather stations to monitor long-term climate fluctuations and is using remote sensing to monitor changes in glacial extent. Cooperators at NASA–Goddard Space Flight Center in Greenbelt, Maryland, have documented an overall reduction in glacier area in Kenai Fjords over the last 30 years and a 3.6% reduction in ice extent from 1986 to 2000 alone. In 2007, cooperators will begin an analysis of glacial extent for a similar 30-year period at Lake Clark. Using aerial photos from the 1950s and 1990s and IKONOS imagery acquired since 2005, network staff will also examine changes in nunatak area across the Southwest Alaska Network. Given the potential for continued glacial recession in southwestern Alaska, the monitoring of nunatak communities may increase scientists' understanding of how once-isolated populations of rare plants respond as nunataks increase in size or become contiguous with larger ice-free regions. As a result, the National Park Service may be better able to maintain the integrity of these communities, even as their boundaries shift. ■

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Environmental and ecological implications of aggradation in braided rivers at Mount Rainier National Park

By Scott R. Beason and Paul M. Kennard

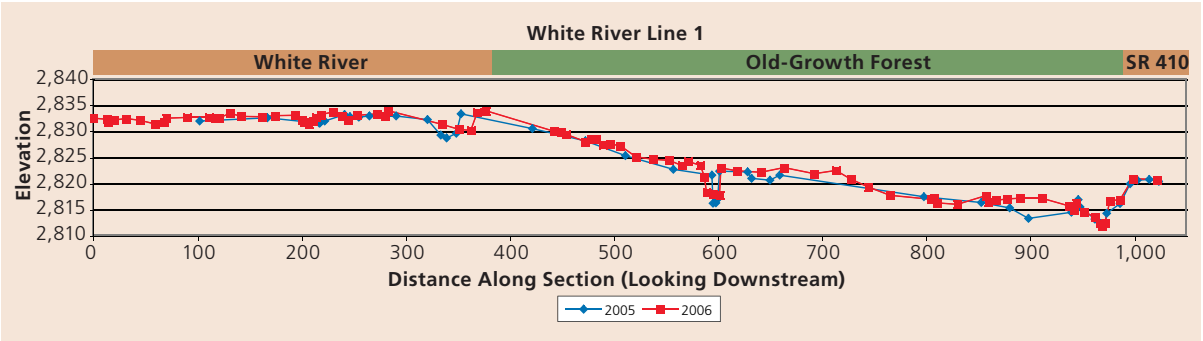
IN NOVEMBER 2006 A MAJOR STORM DROPPED nearly 18 inches (46 cm) of rain in 36 hours at Mount Rainier National Park, Washington. This event caused severe park-wide damage, but the resulting flood was not entirely to blame for the destruction. The geologic setting, physical characteristics of the rivers, and injudicious placement of park infrastructure made the devastation inevitable.

At Mount Rainier, glacially fed braided rivers radiate outward from the 14,410-foot (4,392 m) volcano. These streams carry materials ranging in size from silt to boulders. As gradients decrease away from the mountain, rivers deposit their sediment loads. The height of the river channels rises while streambanks and floodplains remain at their present elevations. Through this process, called aggradation, rivers at Mount Rainier National Park have been inexorably increasing in height over time.

Exact rates of river aggradation in the park were unknown until a 2006 study, which incorporated survey data from 1997 and 2005. Using 1910 longitudinal profiles and historical topographic maps, the National Park Service and cooperating scientists compared current and earlier rates of aggradation, focusing on river areas near popular visitor destinations and primary park infrastructure. Investigators surveyed and created cross sections of current river channels, which they analyzed using Geographic Information System (GIS) software. Depending on the channel slope and confinement, the background aggradation rate of braided rivers at the park is approximately 6 to 14 inches (15 to 36 cm) per decade. At areas in the park with recent debris flows, however, aggradation is much higher. For example, during a single event, approximately 6 feet (1.8 m) of material was deposited over an area of 107,000 square feet (9,940 m^2) in the Nisqually River above Longmire, a primary park visitor and work area.

In many places, park buildings and roads are literally within aggrading rivers, and several locations in the park are below rivers (i.e., one walks uphill to get to the river channel). For instance the bed of the White River is as much as 16 feet (4.8 m) above the surrounding area through which a major highway, State Route 410, passes. Also, the main village at Longmire is 29 feet (8.8 m) below the Nisqually River. This juxtaposition contributed to the majority of the dramatic damage to the park infrastructure following the November 2006 flood. However, the flooding did not "clean" the system of aggrading material, but rather added to it.

As a result of this study, investigators have identified an increasing rate of aggradation in the park over the last 30 years, and attribute this escalation to global climate change. As temperatures increase, glaciers in the park recede. When the ice retreats, it no longer buttresses the steep, unconsolidated lateral moraines and outwash plains, making them prone to landsliding. These types of failures supply rivers with tremendous amounts of sediment and have caused several recent debris flows. Additionally, the results of this study revealed a relationship between suspended sediment load and air temperature at the park. As air temperature increases, sediment provided to the rivers



This cross section shows the elevation of the White River as compared with State Route 410. The river is shown from 0 to 350 feet. The remaining cross section includes an old-growth forest and State Route 410. At this point the river is 2,832 feet (863 m) above sea level (asl), while the road is 2,820 feet (860 m) asl, or about 12 feet (3.7 m) below the river. Just downstream from this location, the difference is 16 feet (4.9 m).

Exact rates of river aggradation in the park were unknown until a 2006 study.

increases exponentially, in the long and short terms. This is scientifically important, because the measured increased aggradation is consistent with climate change. It is also important for park planning because as the global climate continues to warm, more material will be supplied to river channels, further increasing the rate of aggradation.

Though this research has greatly illuminated the process of riverbed aggradation, researchers have just begun to understand the ecological impacts on channel form, aquatic habitats, and riparian succession. Therefore the current research priority is to understand the effects of aggradation on floodplain ecosystems and dynamics. Investigators want to be able to characterize and describe the effects of aggradation on subsurface and surface water flows, channel patterns (i.e., braided, meandering, and straight), diversity and persistence of habitat types, and spatial and temporal dynamics of floodplain vegetation.

Despite many remaining questions, some trends are emerging. Based on observations where the channel bed has aggraded 38 feet (12 m) in the last 100 years, the water table has risen with the bed and the river has not disappeared (i.e., running subsurface below the new sediment deposits). This occurs despite the relative coarseness of the riverbed sediment (coarser sediments are relatively porous and generally support intergranular flow). As a result, fish can still navigate the river, even during low water flow. Additionally, in the last 10,000 years, coniferous forests have been encroaching on valley bottoms, gradually constraining the potential zone of river-channel migration. Recent flooding deposited copious amounts of sediment in these old-growth forests, killing acres of trees and drastically slowing and possibly stopping the rate of valley floor reforestation.

Mount Rainier National Park is an active, dynamic geologic environment capable of dramatic change over short time periods. Most people think of volcanic activity as the principal agent of change in the park. However, as recent flooding and the results of this study show, rivers, by way of aggradation, modify the environment in extreme ways and will continue to present challenges for park planning and development in the years to come. ■

(Top) The braided rivers at Mount Rainier National Park have been aggrading at increasing rates over the past 30 years. Added to the overall aggradation process was sediment deposited during the 2006 flood. Before the flood the space between river level and the bridge over Tahoma Creek was double the amount shown here.

(Bottom) Some reaches of the White River have aggraded to the point of being above the surrounding landscape, including park infrastructure.

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Analyzing the bison genome of Department of the Interior herds

By Natalie Halbert, James Derr, Ron Hiebert, and Peter Gogan

FROM 1997 TO 2002 THE NATIONAL PARK SERVICE and the U.S. Fish and Wildlife Service collected blood, hair, or tissue from 2,260 individual American bison (*Bison bison*) and shipped these samples to Texas A&M University for analysis. Investigators at Texas A&M examined mitochondrial DNA and 49 polymorphic markers (microsatellite DNA) dispersed throughout the bison genome. Now these results are impacting the long-term management of this species and changing the face of bison conservation in North America.

American bison reached an estimated population of 25–40 million on the Great Plains at the beginning of the 19th century. By the late 1820s, however, bison in North America were already in decline as a result of both natural and anthropogenic factors, including the introduction of horses and other exotic animals that increased hunting efficiency and introduced exotic diseases. Moreover, advancements in firearms and transcontinental rail transportation facilitated uncontrolled hide hunting by both aboriginal and Euro-American hunters, which contributed to the rapid population crash of the late 1800s. At the apparent brink of extinction, fewer than 1,000 American bison, including both the plains and wood bison types, existed in the world. Between 1873 and 1904, citizen and government protection of six captive herds and the remnants of two wild herds in the United States (Yellowstone National Park) and Canada (Wood Buffalo National Park) saved the species from this precipitous decline. From these herds a combined total of fewer than 500 bison served as the foundation stock for all bison in existence today. More than 500,000 bison inhabit North America now; most are raised as livestock in private herds. The U.S. Fish and Wildlife Service and the National Park Service manage approximately 6,000 bison in 11 "conservation herds."

The U.S. Department of the Interior (DOI) Bison Conservation Working Group—a consortium of government researchers and managers—has met annually since 1997 to share information about bison management techniques, animal health, policy, genetics, and demographics. This group, which met most recently in 2006 at Fort Niobrara National Wildlife Refuge in Nebraska, recognizes that genetic data are needed to inform management practices, such as whether to manage the DOI herds as separate populations or as a single meta-population. To address this and other conservation issues, managers need to first establish an understanding of the current genetic makeup of these herds, including present levels and patterns of genetic variation within and among herds, the effects of various culling practices on the maintenance of genetic variation, and the level of domestic cattle DNA found in the DOI bison herds.

Federal and university researchers have recently directed much effort at understanding the genetic architecture of American bison (*Bison bison*) herds, which collectively represent some of the most extensive population genetic investigations of any wildlife species.

The small sizes of the DOI bison herds are a major challenge for maintaining genetic variation.

With funding from the U.S. Geological Survey Biological Resources Discipline, Natural Resource Preservation Program, and various U.S. Fish and Wildlife Service sources, the National Park Service and the U.S. Fish and Wildlife Service entered into cooperative agreements with Texas A&M University to conduct genetic studies that would answer management-related questions. Drs. Joe Templeton and James Derr advised the project; Ph.D. candidate Natalie Halbert served as the primary investigator. Additionally, Dr. Guiming Wang (Colorado State University) and Dr. John Gross (NPS Inventory and Monitoring Branch) conducted simulations to prescribe management practices that would maintain genetic health of the DOI herds. Dr. Ron Hiebert and Dr. Peter Gogan served as the NPS and USGS coordinators respectively.

Detailed evaluation of these data indicates that DOI bison herds contain moderate to high levels of genetic variation and show no signs of inbreeding depression. Herd histories explain much of the patterns of variation and relatedness among herds. Multiple lineages that trace back to the original founding herds are represented across the DOI herds, resulting in some of these populations possessing unique genetic characters.

Most of the ranchers involved in saving bison from extinction in the late 19th century were interested in producing hardier breeds of cattle, and records indicate many were directly involved in efforts to hybridize bison and domestic cattle. The two species do not naturally interbreed, but ranchers produced fertile crosses in captivity. Both historical and recent hybridizations between bison and domestic cattle have led to genetic introgression—unnatural introduction of domestic cattle DNA into the bison genome—which significantly complicates bison conservation efforts. Domestic cattle DNA appears in most of the private and state bison herds tested to date. By contrast, less than 1% of the genome of bison in DOI herds is derived from domestic cattle, and no evidence of domestic cattle introgression occurs in bison from either the Yellowstone or Wind Cave herds.

Human-induced environmental and landscape changes have led to the existence of relatively small, isolated populations of many large mammals. The small sizes of the DOI bison herds are a major challenge for maintaining genetic variation. Using the genetic data from Texas A&M University, Wang and Gross found that in excess of 1,000 breeding individuals are necessary to maintain present levels of genetic variation over the next century. Among DOI bison herds, only the Yellowstone National Park herd boasts this size. In addition to increasing population sizes as much as possible, the simulations by Wang and Gross suggested several management changes to reduce the overall loss of genetic variation, such as increasing the generation time by culling the young of the year.

Movement of animals among herds is another management alternative to augment or maintain levels of genetic variation. However, managers must carefully consider this option in order to prevent the spread of wildlife diseases such as brucellosis and to maintain unique attributes found in some populations. Some herds contain evidence of domestic cattle introgression, while other herds have no historical or genetic evidence of hybridization with cattle. Therefore, managers must rigorously evaluate the perceived benefits of transporting animals among herds in light of potentially irreversible effects.

The federal herds have a significant role in the long-term preservation and conservation of bison as a distinct species. These herds serve as the best source of animals for starting satellite populations and restoring plains bison to areas where they can roam freely and be subject to natural selection. The development and implementation of management policies by managers of federal herds may well serve as a model for long-term conservation of other wildlife species. ■

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Determining habitat use and abundance of piping plovers at Padre Island National Seashore

By Michelle Havens and Kristie Landaberde

AT LEAST 10% OF THE WORLD'S POPULATION OF piping plovers (*Charadrius melodus*) migrates through Padre Island National Seashore (Texas) and uses its beach for nonbreeding habitat. Each year these small shorebirds journey thousands of miles between their breeding grounds (i.e., Atlantic coast, Great Lakes, midwestern United States, and Canada) and wintering grounds (i.e., southern Atlantic and Gulf of Mexico coasts), with documented occurrences 12 months of the year at Padre Island. In 1986 the piping plover was declared federally endangered around the Great Lakes and threatened throughout the remainder of its U.S. range. Canada's Committee on the Status of Endangered Wildlife also considers the species endangered. Although these birds have been studied extensively in their breeding grounds, very little research has been conducted to determine appropriate monitoring and protection protocols for them in nonbreeding areas, where they spend nearly two-thirds of the year.

Because the national seashore is a highly important stopover and nonbreeding area for piping plovers, park staff obtained funding to conduct research on piping plover abundance and habitat use. The study began in 2005, and resource employees conducted weekly surveys along the more than 60 miles (96 km) of the Gulf of Mexico shoreline in the national seashore. Since then, National Park Service staff has conducted more than 100 surveys, with more than 5,000 piping plovers observed. In October 2006, biologists conducted two surveys, documenting a total of 588 piping plovers, with an amazing 235 piping plovers along a 5-mile (8 km) stretch of beach during one of the surveys. Overall, more than 80% of the piping plovers were observed foraging alone near the tide line. Numbers this high are unheard of in most other nonbreeding areas. As a result of these numbers, the Western Hemisphere Shorebird Reserve Network selected Padre Island National Seashore as the first National

Biologists combine surveying, color banding, and radio-transmitter tagging in surveys of piping plover at Padre Island National Seashore. During a pilot project from August to September 2006, they banded, radio-tagged, and released two piping plovers. Though the transmitters became nonfunctional within a week, each bird was later relocated near where it had been captured. One of the birds was identified, by color bands, in the same area 32 times since shedding the radio transmitter. This is compelling evidence that piping plovers stay in particular areas of the Gulf of Mexico beach.

Though most often observed foraging alone near the tide line, here a piping plover (in the background) forages near a sanderling (*Calidris alba*). Piping plover density is greatest along the seashore's northern boundary, which is closed to vehicular traffic. Biologists have recorded 31 piping plovers per mile in this area. Farther down the shoreline, rough terrain, coarse-grained sediment, and a narrow beach make the beach unappealing to the birds.

Park System unit to be recognized as a member. Other significant factors in its selection were the ecological importance of the habitat and park staff's commitment to shorebird conservation. The national seashore is included in the network's Binational Laguna Madre Site of International Importance, which includes lands managed by Mexico, The Nature Conservancy, and the U.S. Fish and Wildlife Service.

Park biologists are working with the Canadian Wildlife Service, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and Virginia Tech University to share band sightings and determine survivorship and site fidelity of piping plovers migrating among breeding and nonbreeding areas. Park staff is also partnering with a variety of U.S., Canadian, and Mexican federal agencies, universities, nongovernmental organizations, and the State of Texas to prioritize significant wintering areas and management options for piping plovers along the Texas coast. Color banding and radio-transmitter tagging allow individual identification of birds and make it possible to study the dispersal, migration patterns, and life span of each bird. With approval from the U.S. Fish and Wildlife Service, the National Park Service began to capture and mark piping plovers in late 2006.

With increasing development encroaching upon the national seashore and growing interest in nonfederal oil and gas exploration at Padre Island, this urgent research will fill an information gap and provide documentation for improving management and conservation of piping plovers throughout their range. Future studies are expected to look into shorebird disturbance and lead to such management actions as nonfederal oil and gas mitigation measures, park program management (e.g., beach maintenance), and permitting for recreational activities. Plover research at Padre Island National Seashore is contributing significantly to the understanding of piping plover nonbreeding habitat requirements. As a result, park staff will be able to craft guidelines for park development, provide educational opportunities beneficial to the species, and contribute to the global protection of piping plovers. Specifically, limited access and the potential for resource damage have delayed surveys on the Laguna Madre shoreline of the island, which provides excellent foraging and roosting for nonbreeding piping plovers. As methods to survey the Laguna Madre shoreline are developed, the national seashore has the opportunity to host up to 20% of the world's population of piping plovers during the fall months when the population is thought to surge. ■

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Hurricane Wilma benefits mangrove forests at Everglades National Park

By Kevin R. T. Whelan and Thomas J. Smith III

WE TYPICALLY VIEW HURRICANES AS DISASTERS that cause extensive damage, particularly to infrastructure but also to natural areas such as estuaries, beaches, and barrier islands. However, hurricanes also have ecological benefits, such as dispersing species to new areas; thinning forests, which may favor regeneration by specific species; and flushing bays. Additionally, in 2006, researchers at Everglades National Park (Florida) found that hurricanes added needed sediments to wetlands, in particular the park's mangrove forests. Along the southwestern coast of Florida, the average annual rate of sea-level rise is 0.07 inch (1.9 mm) per year; mangrove forests can keep pace with increasing sea-level rise only if an adequate sediment supply sustains the soil elevation relative to sea level. Hurricanes can provide a sudden pulse of sediment to mangrove communities, which are critical habitat for the park's world-renowned wading bird populations—the primary reason for the establishment of the park. Mangroves also harbor threatened and endangered species (e.g., American crocodile [*Crocodylus acutus*] and West Indian manatee [*Trichechus manatus*]) and are an important nursery for many sport fish.

On 24 October 2005, Hurricane Wilma came ashore between Cape Romano and Everglades City as a category 3 storm, with sustained winds varying from 61 to 103 miles per hour (98 to 166 kph). Prior to landfall, Hurricane Wilma was the third category 5 hurricane of the 2005 Atlantic season but became the most intense hurricane on record in the Atlantic basin. The National

Mangrove forests, including the one at the mouth of the Shark River, cover more than 148,000 acres (60,000 ha) in Everglades National Park, Florida.

Oceanic and Atmospheric Administration National Weather Service Forecast Office estimated Hurricane Wilma's storm surge to be 16 to 18 feet (4.9 to 5.5 m) of water for the mangroves of southwestern Everglades National Park. As reported in *Natural Resource Year in Review—2005*, defoliation by Hurricane Wilma was so severe that researcher Thomas J. Smith expected that the mangroves would continue to die for months after the storm.

On 11 November 2005, investigators from the NPS South Florida/Caribbean Inventory and Monitoring Network and the U.S. Geological Survey sampled the storm deposit from Hurricane Wilma at a long-term soil surface monitoring site. Varying from 1.2 to 2.4 inches (30 to 60 mm) thick, the storm-deposited layer was composed of very fine marine material (1.2 to 1.6 inches [30 to 40 mm]) on top of mangrove leaf matter (0.4 to 0.8 inch [10 to 20 mm]), which hurricane winds had stripped from the trees. Deposition increased the elevation of the soil surface by about 1.2 inches (30 mm). The increase in soil surface elevation from this one hurricane was greater than the measured accumulation at the site for the previous seven years. This event deposited material that will "combat" 16 years of estimated sea-level rise. One year after Hurricane Wilma, investigators resampled the layer and found that minimal erosion (0.33 inch [8.5 mm]) had occurred; approximately 68% of the storm-deposited, soil surface elevation remained. This gain keeps pace with 10 years of estimated sea-level rise. Additionally, numerous fine roots from the mangrove trees now penetrate the storm deposit.

In November 2005, investigators sampled the sediment layer deposited during Hurricane Wilma (red arrow) and the layer of green mangrove leaves stripped by hurricane winds (green arrow). Deposition during Hurricane Wilma is helping the mangrove forests keep pace with rising sea levels. The feldspar marker horizon (white arrow) is an artificial layer that investigators applied to the soil surface. It is slowly being buried in the soil column as sediment is deposited.

The increase in soil surface elevation from this one hurricane was greater than the measured accumulation at the site for the previous seven years.

The material deposited during Hurricane Wilma should have a beneficial impact on the overall soil elevation of the mangroves of southwestern Everglades National Park and will be an important factor for soil dynamics in the near future. Additionally, this deposit will have a lasting effect on soil nutrients and soil hydrological conductivity (how water moves through sediment). It may also change mangrove seedling recruitment and the burrowing fiddler crab (*Uca thayeri*) community. The ecological outcome of Hurricane Wilma in the mangroves of Everglades National Park will be the result of the interaction between the beneficial effect of the storm deposit on soil elevation and the deleterious impacts from large-scale tree damage and mortality. ■

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Understanding salt-marsh dieback in Cape Cod National Seashore

By Stephen Smith, John Portnoy, and Kelly Chapman

IN 2003, WHILE ASSESSING SALT-MARSH VEGETATION as part of Cape Cod National Seashore's Inventory and Monitoring Program, botanist Stephen Smith and ecologist John Portnoy discovered large areas of dead plants in a remote marsh. Subsequently, numerous dieback locations have been documented within the park, in other areas of Cape Cod outside the park boundary, and in other coastal New England states where one to three species of salt-marsh vegetation have been lost. Some biologists have called this phenomenon "sudden wetland dieback" and it has received a great deal of attention from scientists, resource managers, and the news media over the past several years. In Cape Cod National Seashore, mudflats now replace as much as 12% of emergent marsh. In fact, Cape Cod appears to be the "epicenter" of salt-marsh dieback in the Northeast.

During the past year Smith acquired and analyzed hundreds of photographs from 1940 through 2005 and discovered that sudden wetland dieback may not be the new phenomenon it was originally thought to be. He found that progressive losses of salt-marsh vegetation on Cape Cod appear to have been occurring for several decades. However, the reasons for the phenomenon and the implications for salt-marsh ecology are a complex issue. Field observations indicate that factors such as plant debris, ice scouring, grazing geese, and

(Left) The death and disappearance of salt-marsh vegetation appear as brown or beige areas within this Cape Cod marsh.

(Below) High marsh dieback areas are conspicuous as open, brown mudflats amidst healthy lower marsh vegetation that is advancing landward.

As a complement to monitoring of salt-marsh change, a series of field experiments will be conducted in 2007 to test the hypothesis that sea-level rise and peat accumulation are primary causes of dieback in the national seashore.

soil toxicity can be ruled out as primary causes of dieback. Fungi of the genus *Fusarium* may be responsible for diebacks in southern and Gulf Coast states. Drought and snail grazing have been discussed as potential causes in Georgia and South Carolina. At Cape Cod, Smith found that the relict peat in many of the diebacks in the lower-elevation parts of marshes contained roots from *Spartina patens* and *Distichlis spicata*—species that indicate where the high marsh was when sea level was much lower. As *S. alterniflora* advances to higher ground left open by diebacks of the plants there, it gives the impression of dieback, when actually the higher ground species were the first to go. In other words, the retreat of *S. patens* and *D. spicata* from their seaward edge is exceeding the landward advance of *S. alterniflora*.

After several years of field monitoring, greenhouse experiments, and analysis of ground-level and aerial photography, a plausible explanation of salt-marsh dieback is beginning to emerge. For high marsh species it is almost always the lower-elevation (seaward) edge that is dying back. Water level recorders placed in the root zones by Cape Cod's hydrologic technician Kelly Chapman show that high marsh dieback edges are considerably downslope of the mean high tide level, which is considered the seaward limit of their ecological niche. Diebacks also occur in the low marsh; however, *S. alterniflora* losses have occurred at many different elevations between mean low and mean high tide. In general, the most severe diebacks are observed along the banks of large tidal creeks, around the edges of marsh islands, and along elevation breakpoints within the marsh that receive high wave energy. These areas correspond with a significant widening of tidal creeks and losses of marsh edges and islands over the last few decades. In addition, the long-term accumulation of extremely dense peat from the plants themselves may be contributing to a kind of natural decline. Where centuries of accumulated peat has been eroded away by waves or scoured away by ice to expose the much looser underlying sediment (primarily sand), plants are healthy and vigorous.

As a complement to monitoring of salt-marsh change, a series of field experiments will be conducted in 2007 to test the hypothesis that sea-level rise and peat accumulation are primary causes of dieback in the national seashore. Manipulation of ground elevations along the seaward edge of high marsh dieback zones and removal of dense peat reefs in low marsh dieback zones will help national seashore scientists determine the relationship of rising sea levels and peat accumulation to vegetation loss and understand how salt-marsh landscapes are changing as a result of this process. Erosion following dieback events can have enormous implications for recovery, as sediment loss from the marsh and transport to coastal waters can impact nearshore, and potentially offshore, communities. Smith, Portnoy, and Chapman are monitoring erosion rates and hydrology at numerous locations. Initial data reveal that significant losses of elevation are occurring in dieback areas even during periods of calm weather and that certain high marsh edges are inundated more frequently by tides than previously thought.

Severe dieback leads to erosion along the marsh edge.

Careful assessment of Cape Cod's salt-marsh resources has produced a wealth of information on the nature of dieback. This, in turn, has generated great interest within the larger scientific community. Three workshops have been held on the subject and partnerships are being formed with scientists and resource managers from the U.S. Geological Survey, U.S. Fish and Wildlife Service, Connecticut Department of Environmental Protection, Connecticut Agricultural Research Station, Brown University, University of Massachusetts, Marine Biological Laboratory, Massachusetts Audubon, and Massachusetts Coastal Zone Management. The development of this collaborative effort and the science that emerges from it can be directly attributed to the implementation of natural resource inventory and monitoring that will provide the basis for related management and public education. ■

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3 Alliances for Science: Partnerships and Innovation in Resource Conservation

One of the great benefits of the Natural Resource Challenge initiative of the past eight years has been the establishment and growth of scientific institutions that emphasize collaboration in meeting the science needs of the national parks. Serving groups of parks with similar resources and geographic settings, Inventory and Monitoring networks, Research Learning Centers, and Cooperative Ecosystem Studies Units facilitate broad, ecoregional approaches to research, resource management, and resource education. About 10 years old, these key institutions are maturing and, as many of the following articles suggest, are models for effective planning, implementation, and communication of science. Research Learning Centers, for example, have been very successful in coordinating the involvement of citizen scientists in collecting resource inventory data through popular activities called "bioblitzes." The information generated is useful to park managers, and the collaborative experience engages citizens in educational and intellectual ways that deepen their appreciation for national parks. The articles also demonstrate clever educational partnerships that use park examples to teach science and resource management principles as students collect data for park purposes. Other helpful alliances have come about from viewing park resources at the landscape scale. A variety of agencies and conservation organizations with many of the same goals as the National Park Service manage marine and land-based natural and recreational resources. Approaching conservation regionally is efficient and holistic because responses to habitat loss, altered natural processes, and invasive species now incorporate landscape ecology principles. Overall this chapter exemplifies the power of smart, collaborative partnerships in the use of science for the improvement of park management.

"Who but a fool would take his left hand by his right, and say to himself, how d'ye do? Partners! I must have partners!" —Herman Melville

Alliances for science provide new knowledge about park resources

By Leigh Welling

THE NATIONAL PARK SERVICE (NPS) ESTABLISHED the Natural Resource Challenge (NRC) in 1999 as a multiyear and multiprogram initiative to increase science-informed resource management within the Service. Many of the programs established under the Challenge have begun to collaborate in new ways that increase the effectiveness of individual programs and enhance the overall value of the broader NRC initiative. The added value and benefits of these collaborations include increased data for decisionmaking, reduced costs through leveraged funds, shared expertise and resources, enhanced communication with park managers, and better scientific information products for public audiences.

Examples of existing collaborations among three NRC programs—Inventory and Monitoring (I&M) networks, Cooperative Ecosystem Studies Units (CESUs), and Research Learning Centers (RLCs)—are explored below. In 2006 the 32 I&M networks, 17 CESUs, and 17 active RLCs conducted a range of activities that combined expertise and resources from these three programs in innovative ways to help parks meet their science needs. The collaborations can be grouped generally as (1) planning and implementing science and research and (2) science communication. Many other examples and opportunities exist for how these programs can work together to support science-informed decisions.

Planning and implementing science and research

Acquiring new knowledge about park resources and ecosystems is critical for making informed management decisions. In order to accomplish this, park staffs must engage with their partners and resource programs to proactively plan and implement science and research. Collaborative efforts to support parks in this process include identification of park research needs and catalogs, small grant programs that encourage park-based research and create student opportunities to help address the highest-priority information needs of parks, and citizen engagement in baseline data collection and long-term monitoring of resource health.

Monitoring such atmospheric stressors as mercury and nitrogen in the park at high elevations helps Acadia National Park staff assess watershed conditions and contributes to an overall understanding of park health.

Many of the programs established under the [Natural Resource] Challenge have begun to collaborate in new ways that increase the effectiveness of individual programs and enhance the overall value of the broader … initiative.

Identifying research needs in Acadia National Park

In 2006–2007 the Rocky Mountains CESU worked with the Schoodic Education and Research Center to develop a Research Opportunities Catalog for Acadia National Park (Maine). The process included a series of workshops with park managers and scientists to identify research priorities. The catalog will be available in fall 2007 in database form and is coordinated with the prototype Watershed Condition Assessment in progress at the park (see photo, previous page). The catalog will be used by the park, the Schoodic Center, and investigators to address research priorities for Acadia and coastal Maine.

Tehabi interns meet park needs and gain practical experience

For the past five years the Rocky Mountains CESU has worked with the Utah State University Tehabi Student Internship Program to cultivate student work and learning opportunities across national parks, I&M networks, and RLCs in the NPS Intermountain Region. As part of the program, students receive training from park, CESU, and I&M staff at a field camp at Grant-Kohrs Ranch National Historic Site (Montana) and are then assigned to a "mentored" work experience in parks and networks throughout the region.

Citizen science for the common loons of Glacier National Park

The common loon (*Gavia immer*) is a Montana Species of Special Concern. The state maintains the largest breeding population in the West, 20% of which is in Glacier National Park. Because resources for baseline inventories and species monitoring are limited, citizen scientists are helping bridge the information gap by gathering data for state and federal managers. More than 300 volunteers have been trained by staff at the Crown of the Continent Research Learning Center since 2005 to observe nesting habits and reproductive success of loons at lakes throughout the park. The project has received funding through the Glacier National Park Fund and the Rocky Mountains CESU, and data management for the work is being supported in part by staff of the Rocky Mountain I&M Network.

Jami Belt, biological technician at Glacier National Park, trains volunteers in identification and ecology of the common loon.

Science communication

Effective science communication is a key to raising awareness of resource issues, identifying and articulating appropriate management concerns and research questions, and encouraging participation in resource stewardship. Collaborative work includes shared support and sponsorship of research seminars, joint workshops on complex issues, and coordination of a range of communication products for internal and external audiences.

Communicating science in San Francisco Bay Area parks

Scientific information is generated through a variety of sources in the San Francisco Bay Area. Lacking is a comprehensive plan to disseminate this information to the variety of audiences that use it. To address this need, a joint project has been initiated by the San Francisco Bay Inventory and Monitoring Network, Pacific Coast Science and Learning Center, Natural

Resource Program Center Office of Education and Outreach, and Golden Gate National Park Association to develop a comprehensive communication strategy. Goals are to enhance awareness and communicate the efforts and findings of scientific endeavors within the network to both internal and external audiences. The strategy will identify and conceptualize key messages from scientific and resource protection endeavors, enhance communication among network parks, assist transfer of critical information among scientists (including research questions), and extend the reach of scientific information to nonscientists.

Reporting ecological conditions in the National Capital Region

The Integration and Application Network of the University of Maryland Center for Environmental Studies, the National Capital Region Network, and the Urban Ecology Research Learning Alliance have jointly developed an integrated approach to communicate vital signs monitoring concepts and natural resource issues in national parks. They developed a conceptual framework based on the key issues and stressors to park resources and on the visualization of results in a variety of contexts where they can be applied. Using this framework, they are implementing multiple ways to produce a synthesis of the monitoring results that is visual, contextualized, geographically and temporally referenced, and dynamic.

The potential for future collaboration

Though I&M networks and Cooperative Ecosystem Studies Units have established relationships whereby they serve all units in the National Park System, not all parks yet have access to a Research Learning Center. Most of the 17 active Research Learning Centers serve multiple parks and collectively reach around 100 of the 391 units in the National Park System (see map 1). Additional opportunities exist to establish Research Learning Centers (map 2) to link with existing I&M networks and CESU frameworks. This development would enhance the efficiency and effectiveness of Natural Resource Challenge goals and provide a local node for science facilitation and communication serving all national parks. ■

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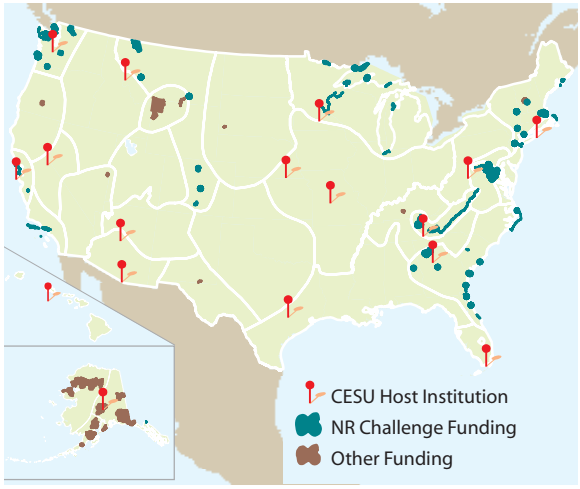
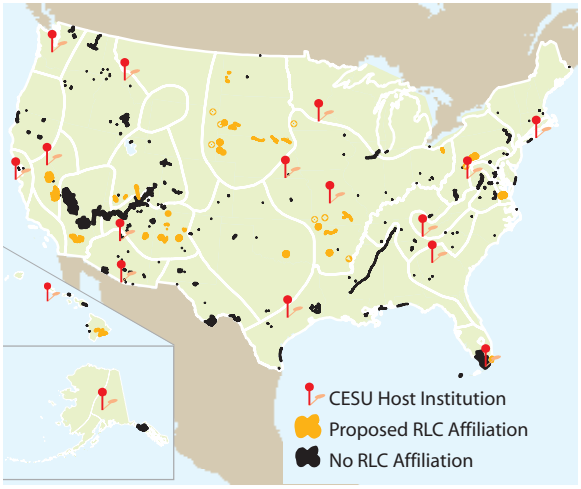


Map 1—The map shows national park units that are served by a Research Learning Center funded by the Natural Resource Challenge (green) or another source (brown). White lines reflect Inventory and Monitoring network boundaries. Host institutions for the 17 CESUs are shown in red.



Map 2—The national parks shown here have opportunities to build stronger alliances for science by funding additional RLCs within existing I&M and CESU networks; parks shown in yellow are affiliated with proposed RLCs and those shown in black have yet to identify an RLC affiliation.

Citizen scientists assist in resource stewardship through Research Learning Centers

By Susan Sachs, Theresa Thom, Joy Marburger, and Sallie Hejl

WHEN IT COMES TO ACCOMPLISHING THEIR SCIENTIFIC goals, researchers in national parks are commonly constrained by time and space—too little time on their side and too large a space to cover by themselves. In 2006, through the development of clear protocols with researchers, staff at several Research Learning Centers in national parks across the country used "citizen scientists" to assist in monitoring, data collection, and research activities. These citizen science programs educate volunteers about resource issues, help managers and scientists obtain valuable data, and allow volunteers to contribute to the stewardship of invaluable park resources.

Introduced in 2000 as part of the Natural Resource Challenge, Research Learning Centers advance research and educational opportunities in national parks and adjacent lands. These centers facilitate public-private partnerships that include a wide range of people and organizations, such as researchers, universities, educators, and community groups.

Global citizen, local volunteer: The Purple Loosestrife Project

The Great Lakes Research and Education Center, established in 2002 to facilitate research and provide educational opportunities in 10 national parks in the Great Lakes region, helps coordinate a project with the U.S. Geological Survey (USGS) that trains citizen scientists in data collection for monitoring the spread of the exotic plant purple loosestrife (*Lythrum salicaria*) in wetlands.

High school students collect data in the ozone biomonitoring garden at the Appalachian Highlands Science Learning Center in Great Smoky Mountains National Park.

The Great Lakes Research and Education Center began sponsoring workshops on purple loosestrife biology and volunteer monitoring in 2003, with more than 51 volunteers and organizers participating since then. Volunteers collect data such as plant height, stem number, presence of flowers, and water depth. Their findings are displayed on the USGS Purple Loosestrife Web site. These studies will help answer questions about the ability of the species to spread in response to climate change, as well as how the plants in Europe may differ genetically from those in North America. Volunteers in seven countries now participate in the project: Australia, Canada, Greece, Tunisia, Turkey, United Kingdom, and United States.

Using students to monitor ground-level ozone

Since 1998 an international team of researchers has been spending one week each year in Great Smoky Mountains National Park (Tennessee and North Carolina) studying the effects of ground-level ozone on plants. Staff at the Appalachian Highlands Science Learning Center are working to determine exactly when plants first begin showing symptoms of ozone damage and the rate of injury progression that occurs before and after field visits. After seeing the research protocols, it became apparent that the process could be taught to middle and high school students. Now in its sixth year, the ozone garden biomonitoring project uses hundreds of students and teachers each year to track ozone effects on behalf of the researchers. Evaluations have shown that students are gaining a deeper understanding of the impacts of an invisible air pollutant, and researchers are gaining a more complete picture of the progression of injury.

Volunteers expand loon observation capacity

Glacier National Park (Montana) has been assessing the status and trends of the common loon (*Gavia immer*), a Montana Species of Special Concern. According to one-day surveys from 1988 to 2004, Glacier National Park provides habitat for 20% of the breeding loons in Montana. The loon reproductive rate, however, appears to be lower than elsewhere in the state and less than that needed to sustain the

population. During 2005 and 2006 the Crown of the Continent Research Learning Center worked with a park wildlife biologist to develop a citizen science program, thus increasing the number of trained people who monitor loon numbers and nesting success throughout the breeding season (see previous article). In 2006, 77 volunteer loon observers (including 33 staff members) conducted 474 surveys on 73 lakes. The results of the study indicated that a season-long population estimate (45 adults, 16 pairs, and 5 chicks) differed substantially from a one-day population estimate (36 adults, 9 pairs, and 4 chicks), which was Glacier's previous standard. Glacier's managers continue to use these data to make decisions about how to manage loon habitat to increase nesting success and loon population numbers. Support for this project was provided by The Glacier National Park Fund, the Rocky Mountains Cooperative Ecosystem Studies Unit, and NPS Volunteer-In-Parks funds.

Ivory-billed woodpecker searches in South Carolina

The ivory-billed woodpecker (*Campephilus principalis*), once the inhabitant of extensive floodplain forests in the southeastern United States and in Cuba, was thought to be extinct, until its apparent rediscovery in Arkansas in 2004. Historical records and recent potential sighting reports brought resources and expertise together to evaluate the possible presence of the woodpecker species in South Carolina. Congaree National Park became a focal point for these search activities.

The Old-Growth Bottomland Forest Research and Education Center at Congaree National Park hosted and coordinated all field activities associated with this effort in 2006. National Park Service staff provided logistical and technical support and played a leading role in training volunteers in bird identification and equipment use. Volunteers experienced Congaree National Park in a special way as they assisted with the search for the ivory-billed woodpecker. Forty-six citizen scientists contributed more than 2,000 volunteer hours as they surveyed approximately 7,210 acres (2,920 ha) within the national park and field-tested search protocols now in use throughout the region. They documented more than 98 species of resident and migratory birds, and though they did not film an ivory-billed, volunteers investigated hundreds of large cavities, foraging evidence, and double-knocks and

In 2006 and 2007, amid giant tupelo and cypress trees, volunteers search the floodplain forests of Congaree National Park for the ivory-billed woodpecker.

other vocalizations that give researchers hope of confirming the existence of the ivory-billed woodpecker in South Carolina.

Citizen scientists integral to science advancement across the National Park System

Seventeen Research Learning Centers now serve more than 100 units in the National Park System. Through their ongoing efforts these centers have enhanced the ability of park managers and staff to make more scientifically sound decisions. The citizen scientists who help support these centers are instrumental in the success of these efforts, allowing NPS researchers to conquer the constraints of time and space. ■

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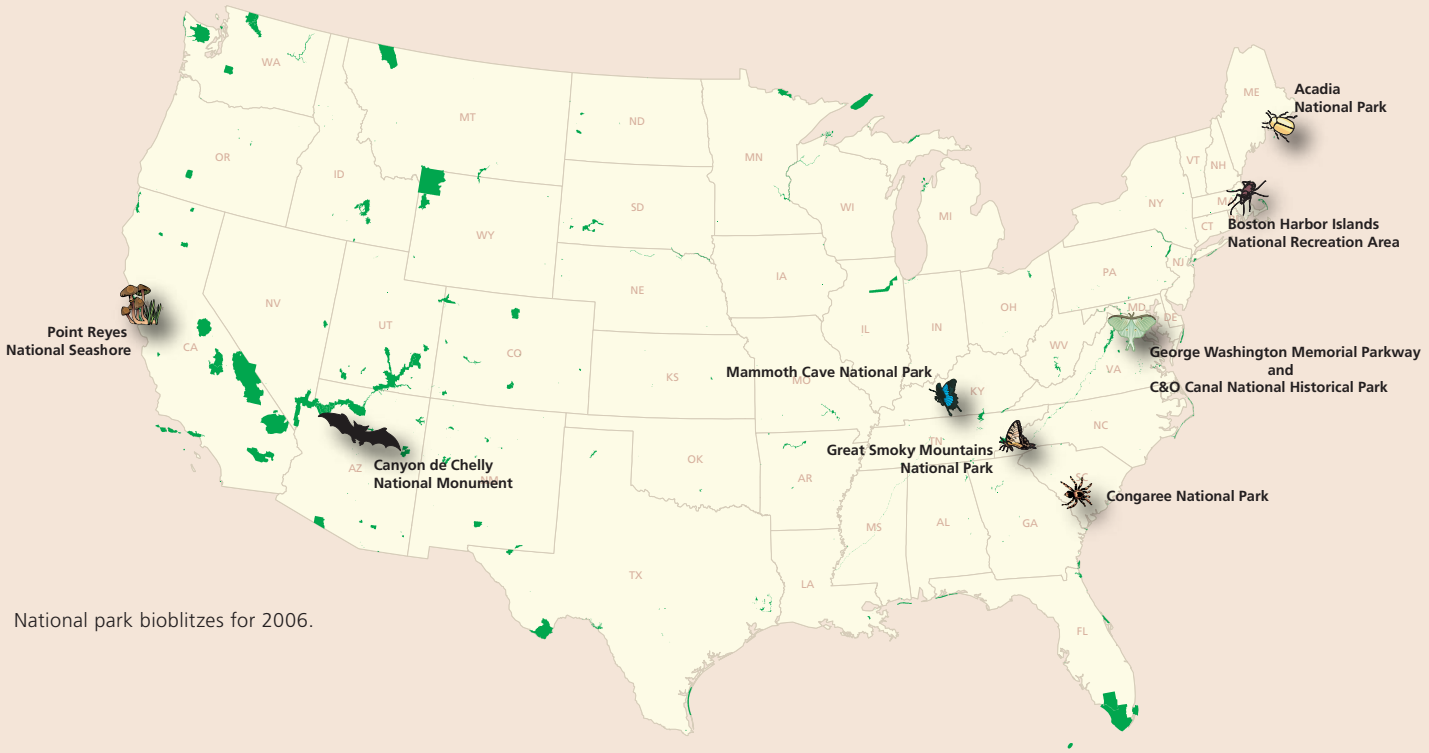
Conserving biodiversity: Bioblitzes focus on the variety of life in the national parks

Tightly defined in time (24 to 48 hours) and space, a bioblitz (also bioquest or foray) brings the diverse capabilities of local natural historians, professional and amateur scientists, and students to the national parks en masse to explore, share findings, and educate the public about biodiversity. In the following articles, organizers with the National Park Service (NPS) parks and Research Learning Centers and their partners share brief summaries of the bioblitz events that took place in 2006 in the national parks. These park units are within coastal, piedmont, mountain, and urban ecosystems. The bioblitzes focused on diverse, often understudied, taxa such as fungi, beetles, and spiders.

Bioblitzes represent important contributions to systematic inventory and monitoring programs and can provide basic data needed for resource protection and conservation, which enhances park managers' abilities to protect resources. The bioblitzes often focus on groups not surveyed through the NPS Inventory and Monitoring Program. Though they do not comprehensively inventory a park's resources, bioblitzes develop important information on species occurrences, richness estimates, and identification of rare, endemic, and invasive species. Such data address the unfunded inventory needs of parks and are an excellent way to identify and help prioritize possible monitoring needs. Among the hundreds of species counted in each event are surprising discoveries of not only rare species but also species new to the park, county, state, region, and to science.

A bioblitz enhances public awareness of biodiversity in national parks. Each bioblitz in 2006 was associated with public programs to build awareness and understanding and to create advocacy for park resources. Bioblitzes facilitate educational and intellectual interactions among participants. They offer students hands-on experience and interaction with career scientists, especially taxonomists, whose numbers are declining in today's institutions but whose skills are needed for managing biodiversity. Broad and diverse media coverage of these events offers excellent, far-reaching venues to discuss conservation and park issues. Additionally, educational programs and curriculum development can follow these bioblitzes. Great Smoky Mountains National Park staff created a high school mentoring program that involved their "Beetle Blitz" researchers.

Bioblitzes not only benefit from volunteers but actually rely on the donation of time from professional taxonomists and experienced amateurs. These partnerships are vital to the parks and increase the richness of the bioblitz experience by bringing together different skills. Partners share the common goals of greater understanding to protect park resources and new interactive and educational outreach opportunities. Volunteers make the events possible through their support and participation on the teams.



National park bioblitzes for 2006.

Congaree SpiderBlitz

By Theresa A. Thom and David C. Shelley

AS PART OF ONGOING RESEARCH AND INVENTORY work at Congaree National Park (South Carolina) the Old-Growth Bottomland Forest Research and Education Center hosted the first ever SpiderBlitz in October 2006. Dr. Robert Wolff, an entomologist at Clemson University, led the program with the assistance of park staff. Volunteers helped with this full day of data collection, and their efforts made the SpiderBlitz a great success. A total of 41 citizen scientists from South Carolina and Georgia donated 135 hours as they learned about, collected, and examined spiders. Following a brief introduction to spiders and how to collect them, citizen scientist teams collected spiders in various park habitats in morning, afternoon, and evening sessions. Specimens were brought back to the Research and Education Center lab, where they were examined under dissecting microscopes. Preliminary results indicate that more than 150 species were collected, with roughly 40 species newly documented in the park. The Congaree SpiderBlitz was the first of what is hoped will be many bioblitzes to be held at Congaree National Park. ■

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Designed to encourage public participation, the Congaree National Park SpiderBlitz introduced volunteer citizen scientists of all ages to a variety of park habitats and led to new species discoveries for the park.

Such data [generated by bioblitzes] address the unfunded inventory needs of parks and are an excellent way to identify and help prioritize possible monitoring needs.

Fungal Forays at Point Reyes National Seashore

By Ben Becker and Christie Anastasia

MORE THAN 200 CITIZEN SCIENTISTS PARTICIPATED in the first ever Fungal Forays at Point Reyes National Seashore, California. This rapid biodiversity assessment was designed to sample fungi from habitats throughout the park to help expand our understanding of fungal distribution and biodiversity. Point Reyes National Seashore is typical of most national parks with a good inventory of its vertebrates and vascular plants, but with little knowledge of its fungal biota. The goal of the Fungal Forays is to address this need and produce a useful database for ecologists while making basic knowledge of the region's fungi publicly accessible. Taxonomists from UC–Berkeley, Humboldt State University, and San Francisco State University and experts from the Mycological Societies of San Francisco and Sonoma counties joined many other enthusiasts and even several park visitors, who participated in the study to round out their park visit. So far the forays have increased the park's species list from 110 to more than 440, with at least 8 species new to science. Because of the ephemeral nature of fungal fruiting structures, the Pacific Coast Science and Learning Center and its scientific partners are repeating the surveys in 2007 and 2008 and expect to find many additional park records. ■

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Laid out on waxed paper and accompanied by collection data, fungi gathered as part of the 2006 Fungal Forays at Point Reyes National Seashore await identification by mycologists.

New bioblitz discoveries in national parks near the nation's capital

By Brent Steury, Stephanie Flack, Mary Travaglini, Arthur Evans, Giselle Mora-Bourgeois, and P. Scott Bell

THE GEORGE WASHINGTON MEMORIAL PARKWAY and Chesapeake and Ohio Canal National Historical Park (Virginia and Maryland) teamed up with The Nature Conservancy's Maryland/DC Chapter on 24–25 June 2006 to conduct a bioblitz on national park lands within the Potomac River Gorge, a 15-mile river corridor that is recognized as one of the most biologically significant natural areas in the eastern United States.

A total of 135 volunteer biologists and naturalists formed 18 field research teams and represented 30 institutions, including the Maryland and Virginia Natural Heritage programs, the Smithsonian Institution, and area universities. The teams focused their surveys on historically undersurveyed groups of invertebrates and nonvascular plants.

Highlights of the 30-hour search include a fly species new to science; new Virginia records for 51 beetles, five true bugs, a fly, a bee, and a copepod; a state rare dragonfly previously unrecorded from the parks; and hundreds of other new park records, including species of land snails, crayfish, flatworms, spiders, syrphid flies, caddisflies, stoneflies, an antlion, wasps, true bugs, moths, beetles, fungi, slime molds, algae, mosses, and vascular plants. ■

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Invertebrates, plants, fungi, and slime molds collected during the Potomac River Gorge bioblitz are sorted and identified in a makeshift laboratory at George Washington Memorial Parkway.

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Great Smoky Mountains Bioquest

By Paul Super and Susan Sachs

GREAT SMOKY MOUNTAINS NATIONAL PARK (Tennessee and North Carolina) held its first bioquest in 2000 as part of its All Taxa Biodiversity Inventory. From 2000 through 2006, more than 30 bioquests have been held, focusing on both taxonomic groups (beetles, fungi, lichens, slime molds) and specific habitats (karst and caves, leaf litter, and high-elevation sites). Over the years the logistics for and focus of bioquests have changed. Most bioquests are now several days long and include better follow-up on difficult identifications and more geo-referenced data for common species. As an important part of bioquests researchers bring their students to study with other experts. Serendipitous results of bioquests include finding new, potentially invasive nonnative species and unusual phenomena (e.g., deformed, acid-loving diatoms in high-elevation springs).

High school student volunteers consult butterfly and moth identification guides in the Lepidoptera Quest at Great Smoky Mountains National Park.

The Lepidoptera (butterflies and moths) Quest is an example of the increased efficiency and productivity of successive bioquests. In 2000 a Lepidoptera Quest brought together researchers, adult volunteers, and high school students to collect 706 species in 24 hours, including 25 undescribed species, producing a checklist. In 2004 a Lepidoptera Quest collected fewer species over four days, but 500 species were digitally photographed, 642 species were submitted for DNA sequencing, and more than 300 species were preserved cryogenically. The 2004 quest produced more than 3,000 geo-referenced records as the researchers are accompanied by volunteers who record GPS locations and associated metadata. ■

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(Above right) Investigators Joe Keiper (left) and Chris Thompson (right) search for flies along the intertidal wrack line at Acadia as part of the blitz.

(Right) Volunteers for the 2006 Schoodic Diptera Blitz at Acadia National Park stand up to be counted.

Acadia National Park Bioblitz

By Jim McKenna

ACADIA NATIONAL PARK (MAINE) HAS HOSTED FOUR annual bioblitzes to document the biodiversity of lesser-known taxonomic groups within the park (ants, butterflies and moths, beetles, and flies). Acadia's bioblitzes have given managers important baselines for use in park management. For example, an Acadia bioblitz is a single 24-hour event conducted in 6% of the park's landholdings. Despite these narrow spatial and temporal boundaries, the fiscal year 2006 Coleoptera bioblitz collected 310 species of beetles, 60 of which were new records for the park and 48 of which were new records for the state of Maine. ■

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Beetle Blitz at Boston Harbor Islands National Recreation Area

By Mary Raczko and Jessica Rykken

IN 2006 A 24-HOUR BEETLE BLITZ CONTRIBUTED TO the Boston Harbor Islands National Recreation Area (Massachusetts) All Taxa Biodiversity Inventory (ATBI). The park organized the event and partnered with the Harvard Museum of Comparative Zoology, the Thompson Island Outward Bound Education Center, and the Island Alliance. Despite consistent rain for the first 18 hours of the event, 30 people, including professional researchers, amateur entomologists, students, a representative from Taiwan National Parks, and a youth group from Ohio, collected 205 beetles from two islands. At least 20 of the 70 species collected are new records for the park. On Thompson Island, citizen scientists were led by park rangers and helped collect specimens while learning about the "micro-wilderness" of the islands. A smaller group of participants braved the wind and rain to venture to Lovells Island by boat for more collecting. Public contributions to the ATBI continued throughout the year through school programs, nature walks, and camping programs. Volunteers will soon be able to follow up on the results of their efforts via a publicly accessible database. ■

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Volunteers search for beetles, including the six-spotted tiger beetle (*Cicindela sexguttata,* inset), at Boston Harbor Islands National Recreation Area.

Canyon country critters discovered at Canyon de Chelly National Monument

By Elaine F. Leslie

SITUATED IN THE HEART OF THE NAVAJO Reservation, Canyon de Chelly National Monument (Arizona) initiated two bioblitzes in 2005 and followed up with coordinated All Taxa Biodiversity Inventory (ATBI) efforts in 2006. Park staff united with the surrounding Navajo Nation volunteer community of Chinle and Tsaile to conduct inventories of raptors, riparian avifauna, bats, and invertebrates. Diné College and Northern Arizona University students joined in the work. Park staff and students are being trained in the methods of field collection, preservation, and cataloging. In 2006 alone the park collected more than 5,000 specimens, including 470 arthropod taxa, 6 bat species new to the park, and several raptors that were once thought to be migratory but are now confirmed as residents.

Bat blitz participants document a rare spotted bat (*Euderma maculatum*) at Canyon de Chelly National Monument.

The park, with the assistance of Neil S. Cobb, director of the Merriam-Powell Center for Environmental Research, will feature a 2007 ATBI workshop to teach students of all ages about the natural history of species like tarantulas and scorpions, resulting in an expected fivefold increase in collection of arthropods by the end of the summer. ■

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A biologist checks a moth trap and provides public orientation at the Butterfly Blitz at Mammoth Cave National Park.

Butterfly Blitz continues to add species at Mammoth Cave National Park

By Kurt Helf

TEN AMATEUR LEPIDOPTERISTS; RICK OLSON AND Kurt Helf, ecologists with Mammoth Cave Science and Resources Management Division; and Jeffrey Marcus, assistant professor at Western Kentucky University, participated in the second Butterfly Blitz at Mammoth Cave National Park (Kentucky). The blitz was held 7–9 July 2006 and added 23 species and likely hundreds of moth species to the park list. In addition, Drs. Marcus and Helf helped the public learn names and characteristics of butterflies and moths. Twenty-five visitors, ages 6 to 60, armed with nets, patrolled the park trails during the day to observe, capture, and identify butterflies. They checked baited traps left the night before for additional moths and butterflies. In the evenings, Dr. Marcus used a mercury-vapor lamp and white sheet to attract night-flying moths. During the first Butterfly Blitz (in 2005), researchers, students, and visitors documented 58 butterfly and 800 moth species, with hundreds of additional specimens waiting to be identified. They discovered one moth new to science, one rare Olympia marble butterfly (found only in four populations in Kentucky), and two moth species that are each found in only one other location in the state. ■

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Science meets history: Cooperative Ecosystem Studies Units create opportunities for innovative collaborations and improved understanding

By Christine Whitacre, Kathy Tonnessen, Trinkle Jones, Ron Hiebert, Pat O'Brien, and Larry Norris

COOPERATIVE ECOSYSTEM STUDIES UNITS (CESUs) are research centers that allow universities, federal land management agencies, and other partners to work collaboratively to produce research, technical assistance, and educational opportunities designed to address complex resource issues. In recent years the numerous CESU partners working within the National Park Service (NPS) Intermountain Region have provided specialized assistance to meet the science and history needs of the region's national parks. Additionally, by linking natural and cultural resources research, these parks have had the opportunity to work creatively with university departments that have not traditionally participated in park research. As a result, a number of projects have been undertaken through CESUs in the NPS Intermountain Region from 2002 to 2006 that foster innovative collaboration and use science to enhance the understanding and preservation of culturally significant natural resources.

For example, the Desert Southwest CESU has undertaken collaborations that will help to protect natural and cultural resources and promote heritage tourism. In 2003 the University of Arizona, the Arizona–Sonora Desert Museum, and the National Park Service collaborated on plans to inventory and preserve Spanish colonial botanical stock that today still propagates and grows in Arizona and Sonora, Mexico. During the Spanish colonial missions era, settlers brought to Arizona domestic plants—apple, peach, apricot, pear, quince, persimmon, grape, and similar species—that survive today. Similarly, in northern Mexico, missionaries like Father Eusebio Francisco Kino established missions with working farms and orchards during the first half of the 17th century. Based on the research and preservation efforts of Desert Southwest CESU partners, historical agricultural sites such as orchards will be reestablished at two sites near Tucson, Arizona: Tumacacori National Historical Park and Tucson Origins Heritage Park. Other partners working to preserve these historical agricultural resources include the NPS Western Archeological and Conservation Center and Mexico's Instituto Nacional de Antropología e Historia.

In 2005 and 2006 the Colorado Plateau CESU administered and partially funded three projects to improve the management and care of entomological, paleontological, and other natural history collections stored at Colorado Plateau national parks and other partner institutions, including Northern Arizona University and Colorado State University. Within the National Park Service, collections management has been a cultural resource management function; however, many parks have extensive natural history collections that include type specimens for new species and rare natural resource items. As a result, natural resource collections, such as the 4,500 moth and butterfly specimens at Colorado National Monument, benefited from the expertise of CESU partners who helped to catalog and improve the storage of various collections. Additionally, new species were discovered among the existing collections, which were documented and published for the first time.

Through the Rocky Mountains CESU, in 2005 the University of Colorado at Boulder partnered with Sand Creek Massacre National Historic Site (Colorado), the National Park System's newest park, to explore the cultural and natural landscape that was present at the time of the massacre, which the park was created to preserve and memorialize. On 29 November 1864, U.S.

At Sand Creek Massacre National Historic Site (Colorado), scientists with the Rocky Mountains CESU used dendrochronology, or tree-ring dating, on existing stands of riparian cottonwood trees to identify "witness trees" that may have been alive at the time of the 1864 massacre that the park was established to memorialize.

Researchers working at Sand Creek Massacre National Historic Site were unable to definitively date any of the 92 standing trees they studied to 1864, the year of the massacre; however, the tree pictured is estimated to have germinated in 1865, one year after the massacre.

Collaboration between the National Park Service and highly qualified CESU partners is proving invaluable for improving the understanding and protection of the cultural resources found in our national parks.

volunteer soldiers attacked a village of Cheyenne and Arapaho Indians. Because the park's authorizing legislation calls for the National Park Service to protect the cultural landscape of the site as it appeared at the time of the massacre, NPS scientists and university partners used dendrochronology, or tree-ring dating, on existing stands of riparian cottonwood trees to identify "witness trees" that may have been alive at that time. Though none of the standing trees were definitively dated to 1864, the evidence suggests that a number of cottonwoods were alive at the time as seedlings or saplings. This study also provided historical climatic reconstructions related to floods and droughts that affected these cottonwood stands over the past 150 years. For example, scientists were able to determine that the limited establishment of cottonwood seedlings along the park's Big Sandy Creek was the result of drought, lack of large floods, and land-use practices of the last 50 years. These data sets will be pivotal in drafting a general management plan for the new park that will preserve and protect both natural vegetation communities and the cultural context for this nationally significant historic site.

Clearly collaboration between the National Park Service and highly qualified CESU partners is proving invaluable for improving the understanding and protection of the cultural resources found in our national parks. When science meets history, it is possible to understand not only the natural processes that shaped history but also how to better preserve the cultural resources in our care. ■

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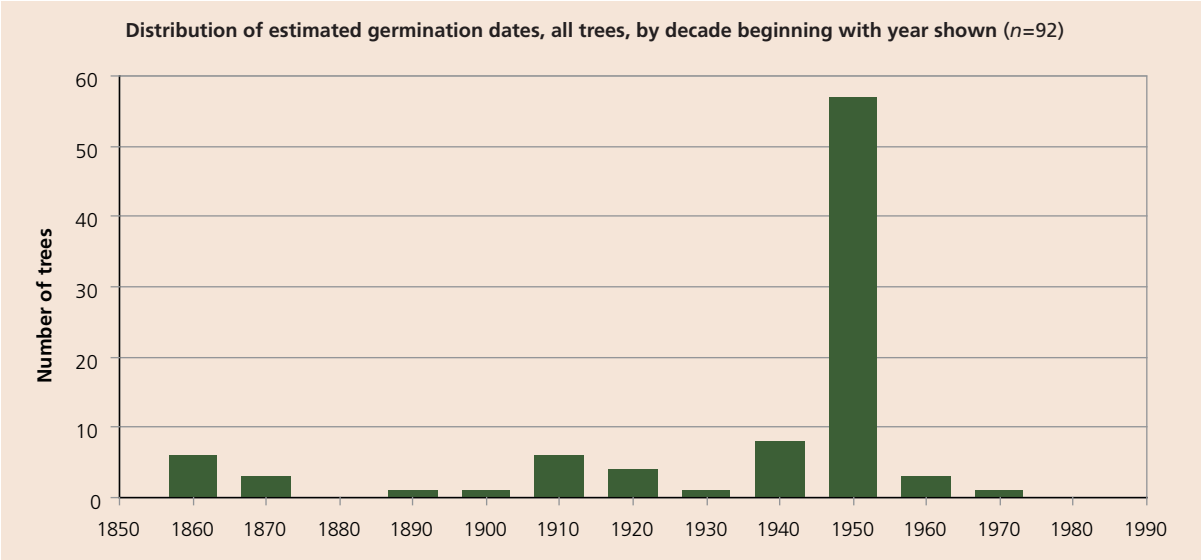

The graph shows that there has been very little establishment of cottonwood trees along Big Sandy Creek in Sand Creek Massacre National Historic Site since about 1965. Scientists have determined that this pattern is the result of drought, lack of large floods, and land-use practices during the last 50 years. Data of this sort will be used to inform the park's general management plan.

The NPS Data Store: Improving resource management through data sharing

By Chris Dietrich

NATURAL RESOURCE RESEARCH AND MANAGEMENT

in national parks both require and generate data. A typical field project may involve a literature search, a database of field observations, and maps and reports that document findings. An ongoing challenge in the National Park Service (NPS) has been ensuring that such information can be shared reliably and used to inform resource managers. The Natural Resource Geographic Information Systems (GIS) Program, located at the Natural Resource Program Center in Fort Collins, Colorado, has developed a Web-based application called the NPS Data Store that national parks and programs can use to consistently document and distribute data they generate.

The NPS Data Store (http://science.nature.nps.gov/nrdata/) is a Web-based clearinghouse of data sets and their associated descriptive documentation (metadata). Containing more than 20,000 metadata records, the Data Store catalogs databases, GIS layers, base maps, data standards, and natural resource monitoring protocols. In most cases it provides direct download links so that data sets can be immediately retrieved by users. The Data Store shares data in several ways to make it easily available to researchers, GIS specialists, and resource managers. Data are typically found by performing a search using the application interface. The Data Store also provides Web services to deliver data to national parks and programs. The NPS Metadata Tools and Editor, a companion metadata editing tool for the Data Store, provides the means to document a data set and format the metadata so that they are compatible with NPS and other national systems.

Integration and data sharing

In 2006 the NPS Data Store began an exciting new phase by actively integrating with partners using Web services. Web services deliver metadata to other Web applications so that data cataloged on the Data Store are shared with a broader audience. The Data Store began providing records to GOS, the federal Geospatial One-Stop (http://gos2.geodata.gov/wps/portal/gos), in January. Sharing data via GOS represents a great stride in fulfilling National Park Service obligations to participate in the National Spatial Data Infrastructure and makes data easily available to many more users.

Over the course of the year, three Inventory and Monitoring Program (I&M) networks also established Web services between their Web sites and the Data Store. For example, the Northeast Temperate Inventory and Monitoring Network (NETN) sends a query over the Web that returns search results from the Data Store. Users see metadata with data download links delivered from the Data Store directly on the NETN data access Web page (http://www1.nature.nps.gov/im/units/netn/data/data.cfm). The query results are updated as frequently as records are updated on the Data Store. Fred Dieffenbach, NETN data manager and biologist, explains the value of Data Store Web services: "The data access page developed by the Northeast Temperate Network helps park staff and cooperators find relevant data easily. It also shows that data and metadata standards are not simply arbitrary requirements, but are instead important components that make it possible to share and use NPS data."

These integration efforts are major milestones in NPS efforts to minimize data redundancy, improve efficiency, reduce duplication of effort, and facilitate access to data for park planners and resource managers.

Sensitive or very large data sets

The Data Store can also make data discoverable without making them immediately available online. Examples include data sets that are too large to easily download or that contain sensitive information like locations of endangered species, cultural resources, or fossils. Brian Witcher, South Florida/Caribbean Inventory and Monitoring Network data manager, says: "One of the real values of the Data Store is the ability to make all NPS data discoverable. This is critical for researchers interested in understanding and protecting park resources. Sensitive data can be found by NPS cooperators and the public and still be protected." Through the metadata record, researchers and contractors to the National Park Service can see that these kinds of data exist. Sensitive data are still safeguarded because acquiring them necessitates contacting the person responsible for managing the data.

Single point of access

The Data Store directly supports resource management by providing a single point of access for data spanning a wide range of subjects. This makes it easy to bring

The Data Store has proven to be an effective and reliable tool for sharing data, improving resource management, and preserving institutional memory.

together data from multiple disciplines for analysis and resource management efforts. One recent project at Canyonlands National Park (Utah) used data produced by two different Inventory and Monitoring Program resource inventories to support fieldwork for a third inventory. GIS specialists Aneth Wight and Gery Wakefield depend on the Data Store as a source for developing maps for resource management projects. They used it to find GIS layers produced by the Base Cartographic and Geologic Resources Evaluation inventories. The two data sets were combined to create a map identifying sampling locations for fieldwork supporting the Vegetation Mapping Inventory.

The Data Store is becoming widely recognized by resource managers and researchers as the place to go for NPS data. Brent Frakes, Rocky Mountain Inventory and Monitoring Network data manager, says: "A number of cooperators from research institutions and other government agencies have contacted me about initiating resource-related projects in parks. When I talk to them I often discover that they have already found relevant data sets on the NPS Data Store without me directing them there. The Data Store is a well-known source for NPS data sets of all kinds."

Repository for long-term knowledge

Another way the Data Store improves resource management is by capturing the many years of knowledge and expertise accumulated by long-serving NPS employees. Documenting legacy data sets with metadata posted on the Data Store makes data available that might otherwise remain undiscovered in someone's office. Once entered in the Data Store, these data will remain available for years to come. And as employees move within the National Park Service, having the Data Store as a single point of access for data streamlines data management and keeps data easily accessible regardless of a person's physical location.

The Data Store has proven to be an effective and reliable tool for sharing data, improving resource management, and preserving institutional memory. Using Web services to deliver data to national park units and programs, the Data Store provides resource managers with dynamic access to Service-wide information from a single source. The Data Store also enhances the NPS knowledge base, preserving it for long-term use by the National Park Service and others. By integrating with other NPS and federal data systems using Web services, the Data Store makes data available to a wide range of potential data users and positions the National Park Service as a leader in information technology and data sharing. ■

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A technician collects vegetation mapping data using a Global Positioning System unit along the Fairyland Trail in Bryce Canyon National Park, Utah. The data will be used to generate a vegetation classification for the park and will be stored and shared on the Data Store, a standard procedure for vegetation inventories conducted under the Inventory and Monitoring Program.

Emergency resource assessments integrated with incident management teams

By Dave Anderson, Rebecca Beavers, Erv Gasser, Dan Pontbriand, Pam West, and John Yancy

WHEN SEVERE STORMS, FLOODS, WILDFIRES, OR other hazards affect a national park, the National Park Service (NPS) needs to account for not only the well-being of park visitors and its employees but also the natural and cultural resources in its care. For decades the incident command system has provided a familiar and flexible framework for managing responses to these occurrences, including fire suppression and other large-scale emergency activities. In 2005 this system was used to assist parks affected by hurricanes. For the first time, All Hazards Resource Advisors, who include natural and cultural resource specialists, participated in the incident management teams (IMTs) deployed to the affected national parks. They conducted rapid resource assessments to identify damage and minimize further risk to resources, prevent their loss, and begin restoration as soon as possible.

Reported in the 2005 edition of *Natural Resource Year in Review*, this function was largely successful, though many areas for improvement were identified. One need was to establish and train All Hazards Resource Advisors, who would be at the ready to assist park and incident managers with planning and decision making during such emergencies. Fortunately, 2006 did not bring landfall of a major hurricane to the National Park System. An advisory group used this opportunity to develop a qualification standard, training course, and a position task book; these materials were drafted in early 2007 through the All Hazards Incident Management Program and are now near publication.

An important part of planning for and refining emergency response procedures for the protection of natural and cultural resources was the development of a workshop to train the first All Hazards Resource Advisors. Held in Savannah, Georgia, 13–15 June 2006, the training was funded by the Natural Resource Preservation Program and the Recreation Fee Demonstration Program. Subject-matter experts (NPS employees from throughout the Park Service) presented in-depth information about hurricane dynamics, processes, and impacts on natural and cultural resources. An exercise helped participants prepare for an emergency assignment by reviewing protocols for interacting with an IMT and potential response-related health and safety issues.

Two primary themes of the Savannah workshop were (1) to summarize the incident command system and NPS policies related to emergency response and (2) to discuss how two existing emergency teams are models for All Hazards Resource Advisors in the All Hazards Incident Management Program. The Burned Area Emergency Response (BAER) Program is an important element of the wildland fire community; however, use or deployment of BAER Teams is limited to fire. The Museum Emergency Response Team (MERT) developed out of need during past disaster recovery efforts and continues to evolve.

Both teams are specialized and operate first to protect life and property and then to secure and stabilize cultural and natural resources. For example, the BAER Teams (two are established as standing national interagency teams) consist of 13 individuals representing 10 disciplines (hydrology, soil science, geology, archaeology, botany, wildlife biology, forestry, Geographic Information Systems, environmental protection, and documentation), along with team leaders. The process developed by the teams can be adapted to any hazard and includes identifying issues, resources at risk, and needed expertise; conducting resource assessments; preparing treatment specifications; and implementing protection treatments. The process also encompasses developing the funding strategy, setting priorities, identifying and addressing environmental sensitivities, and coordinating activities with park staffs, incident managers, and others. The Savannah workshop introduced participants to this process, which they applied to the exercise.

The training workshop was a success, with 37 specialists taking part; most were Southeast Region staff, but representatives from all but two NPS regions attended. Additional participants were from a variety of Department of the Interior (DOI) and NPS divisions and programs, including the Geologic Resources Division, Spill Response Program, Environmental Health Program, Environmental Protection Program, Emergency Services, Museum Resource Center, DOI National BAER Program, and USGS Office of Emergency Operations.

After the training, Southeast Region staff selected a core group of All Hazards Resource Advisors to support an IMT for future emergencies. The team's first priority is to protect life and property while minimizing resource damage during initial efforts. The

Soil scientist Norm Ambos of the USDA Forest Service surveys a forest fire burn area for slope aspect and potential volume of sediment release from future rainfall. Scientific expertise, long a part of the Burned Area Emergency Response Program, is now available through the All Hazards Resource Advisors team for other types of natural disasters, such as flooding and hurricanes, to help protect and stabilize national park resources.

second priority is to stabilize threatened and endangered resources, especially historical and sensitive ones. The third goal is to develop accurate damage cost assessments in a timely manner, including the cost to recover and restore resources to their original condition, if possible, which can continue long after the emergency.

Resource managers in 2006 also developed a process for activating the All Hazards Resource Advisors team or particular expertise within the team. Little more than a month after the training, Tammy Risius, one of the new All Hazards Resource Advisors, applied her skills in response to a 22,000-gallon oil spill on the Savannah River near Fort Pulaski National Monument, Georgia. With the U.S. Coast Guard taking the lead in the spill response, Fort Pulaski staff and Risius assisted with incident command. Environmental Quality Division staff supported the entire response and damage assessment process, identifying potential funding sources for the park to recover costs.

Though cultural and natural resources have been recovered following past emergencies, this important responsibility cannot be left to chance. Park staffs must continue to be proactive—before an emergency—to safeguard as many resources as possible. When disaster strikes, incident managers will be able to call on the All Hazards Resource Advisors team to conduct timely, on-site assessments. Appropriate expertise will be activated promptly and contribute to team efficiency and cost-effectiveness. This new capability provides a better opportunity for the National Park Service to preserve and rehabilitate park resources that are threatened by disasters. ■

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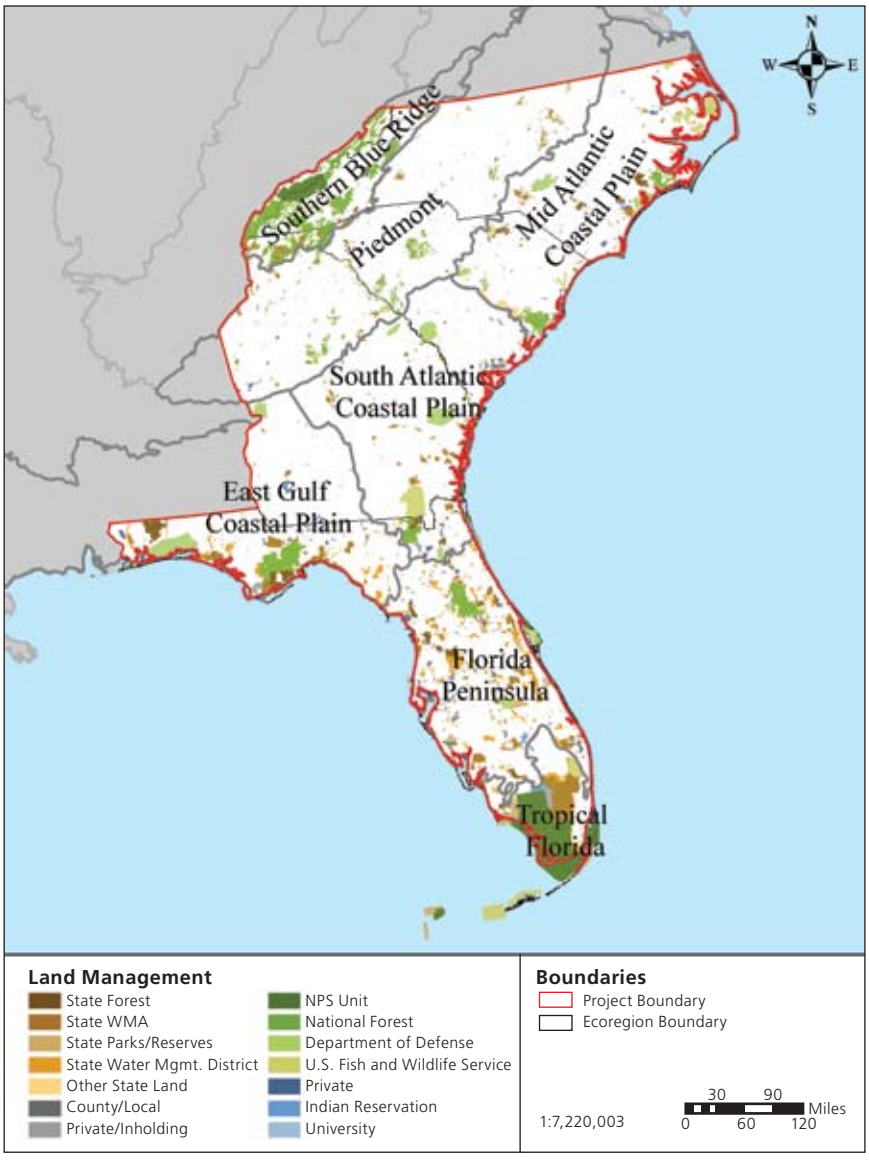
Seamless Network pilot project identifies needs and opportunities for the National Park Service to work at the landscape scale

By Marcos Robles and Greg Eckert

THE NATIONAL PARK SYSTEM ADVISORY BOARD IN 2001 recommended that the National Park Service (NPS) "serve as a catalyst to encourage collaboration among public and private park and recreation systems at all levels—to build a national network of parks and open space across America." The urgent need for collaboration is driven by an increasing number of challenges. Not only are landscapes changing and being rapidly developed, leading to habitat loss, fragmentation, and altered natural processes, but also the introduction of invasive species is changing natural communities and diminishing the quality of the experience for park visitors. From 2004 to 2006 the NPS Natural Resource Program Center; the NPS Southeast Regional Office; national, state, and county park staffs; and partners identified needs and opportunities to develop conservation and recreation networks based on landscape ecology principles applied at broad spatial scales. Known as the Southeast Seamless Network of Protected Areas (Seamless Network), the effort focused on biodiversity conservation, invasive species management, and resource-compatible recreational opportunities in Georgia, Florida, South Carolina, and North Carolina.



The map shows the project area for the Southeast Seamless Network of Protected Areas, which includes parts of seven ecoregions in Georgia, Florida, South Carolina, and North Carolina. From 2004 to 2006 the NPS Natural Resource Program Center; the NPS Southeast Regional Office; national, state, and county park staffs; and partners worked to identify needs and opportunities to develop conservation and recreation networks, developing more than 40 initiatives to address biodiversity conservation, invasive species control, and recreational opportunities.

The Seamless Network project placed national parks in a landscape context in order to understand their role in regional conservation and recreation programs, developing opportunities to work in partnership with multiple agencies, and promoting better natural resource management and enhanced recreational opportunities. In order to reach these goals, project leaders used a five-step process.

As a first step the Seamless Network project staff evaluated a suite of conservation and recreation frameworks and existing initiatives to determine the factors contributing to successful collaborations. The initiatives investigated include conservation sites in the ecoregional portfolios of The Nature Conservancy, the Southeast Ecological Framework of the U.S. Environmental Protection Agency, Important Bird Areas of Audubon, statewide recreation plans, and recently developed statewide wildlife plans. The next step was to identify and nurture the regional conservation approach.

In 2005–2006, project leaders held stakeholder workshops throughout the Southeast during which management partners developed more

Network-based conservation and recreation projects provide economies of scale; help land managers focus on common management issues, ecological threats, and constituent needs; and create a culture within and across agencies that is outcome-focused, regardless of administrative boundaries.... The National Park Service, through its mission and management units, has a unique role to play in developing and supporting landscape networks.

than 40 initiatives to address biodiversity conservation, invasive species control, and recreational opportunities. They produced 11 initiatives that primarily address recreation, 7 for invasive species, and 24 that concern biodiversity conservation. Common strategies are planning for conservation and recreation, acquiring land, developing multiagency cooperative arrangements, leveraging information technology and management tools, and establishing multiagency inventory and monitoring networks.

After completing this work, project leaders further evaluated existing large-scale partnerships and opportunities, such as the Southern Appalachian Man and the Biosphere Program, the Greater Okefenokee Association of Landowners, and the Florida Gulf Coastal Plain Ecosystem Partnership. The team then listed lessons learned and grouped them into a set of recommendations for appropriate scales of work. Recommendations include the development and use of spatial data sets and Geographic Information Systems–based analytical tools; the provision of incentives and support to unit managers to participate in networks, including training on how to participate in networks; and development of landscape-scale conceptual models of resource dynamics or recreational opportunities that include non-NPS units managed by partners.

It is clear that coordination and information sharing are very valuable, but they have their limits. Funding sources to support partnerships need to be made available to parks, including funding to support third-party nongovernmental organizations that can facilitate public agency actions. Nongovernmental organizations will also be critical to advancing landscape-scale approaches with private landowners—the most significant contributors to landscape dynamics that were not included in the Seamless Network pilot project.

Land managers understand that challenges facing parks are the driving forces behind landscape-scale conservation and recreation initiatives. Additionally, emerging directives to develop strategies that accomplish the NPS mission in light of climate change increase the imperative to advance networks. Network-based conservation and recreation projects provide economies of scale; help land managers focus on common management issues, ecological threats, and constituent needs; and create a culture within and across agencies that is outcome-focused, regardless of administrative boundaries. Networks also foster creativity that can lead to better solutions to management issues. The National Park Service, through its mission and management units, has a unique role to play in developing and supporting landscape networks. ■

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Parks and refuges sign oceans agreement with National Oceanic and Atmospheric Administration

By Cliff McCreedy

OCEAN RESOURCE MANAGERS ARE CONFRONTED BY a range of complex issues, such as overfishing and pollution, that cut across the boundaries of marine protected areas. Increased coordination between state and federal agencies will be needed to develop meaningful solutions to these challenges. On 21 August 2006, senior officials of the U.S. Department of the Interior (DOI) and the National Oceanic and Atmospheric Administration (NOAA) signed a new general agreement, known as the seamless network agreement, to coordinate activities and increase partnerships in more than 200 federally managed marine protected areas.

From above the Arctic Circle to below the equator, national parks, refuges, marine sanctuaries, and estuarine reserves conserve a rich assemblage of coastal, ocean, and Great Lakes resources. Although these protected areas are managed by different agencies and were created under separate authorities, they share similar resource management concerns. For example, the Florida Keys includes four national wildlife refuges, three national park units (Dry Tortugas National Park, Biscayne National Park, and Everglades National Park), the Florida Keys National Marine Sanctuary, and the Rookery Bay National Estuarine Research Reserve, all of which protect various habitats of the same ecosystem.

"The general agreement mandates that we work together to protect these invaluable natural and cultural resources," said Kameran Onley, assistant deputy secretary, U.S. Department of the Interior. "We will now be more effective in our ability to attain greater results through the exchange of agency resources."

Marine Management Specialist Cliff McCreedy, National Park Service Water Resources Division, worked with DOI and White House Council on Environmental Quality staffs to develop this initiative as part of the president's U.S. Ocean Action Plan. The agreement will directly benefit national parks by enabling parks, refuges, sanctuaries, and estuarine reserves to exchange funding, assets, information, and technical support where they physically overlap, adjoin each other, or confront similar issues. Many parks and sanctuaries already share resources in a variety of ways. The seamless network agreement is designed to facilitate and enhance scientific understanding and conservation of coastal and marine resources by increasing coordination among federally managed protected areas and with state, public, and private partners.

The seamless network agreement is designed to facilitate and enhance scientific understanding and conservation of coastal and marine resources by increasing coordination among federally managed protected areas and with state, public, and private partners.

During the first year, plans will be developed to address priorities identified in the agreement, including research, monitoring, enforcement, education, and outreach. In addition, a pilot regional workshop will be conducted to identify local priorities and projects that are consistent with the areas of focus in the agreement. Agencies will explore how to coordinate and facilitate financial and administrative activities to allow a timely transfer of funds and effective sharing of facilities, vessels, equipment, personnel, and other resources. ■

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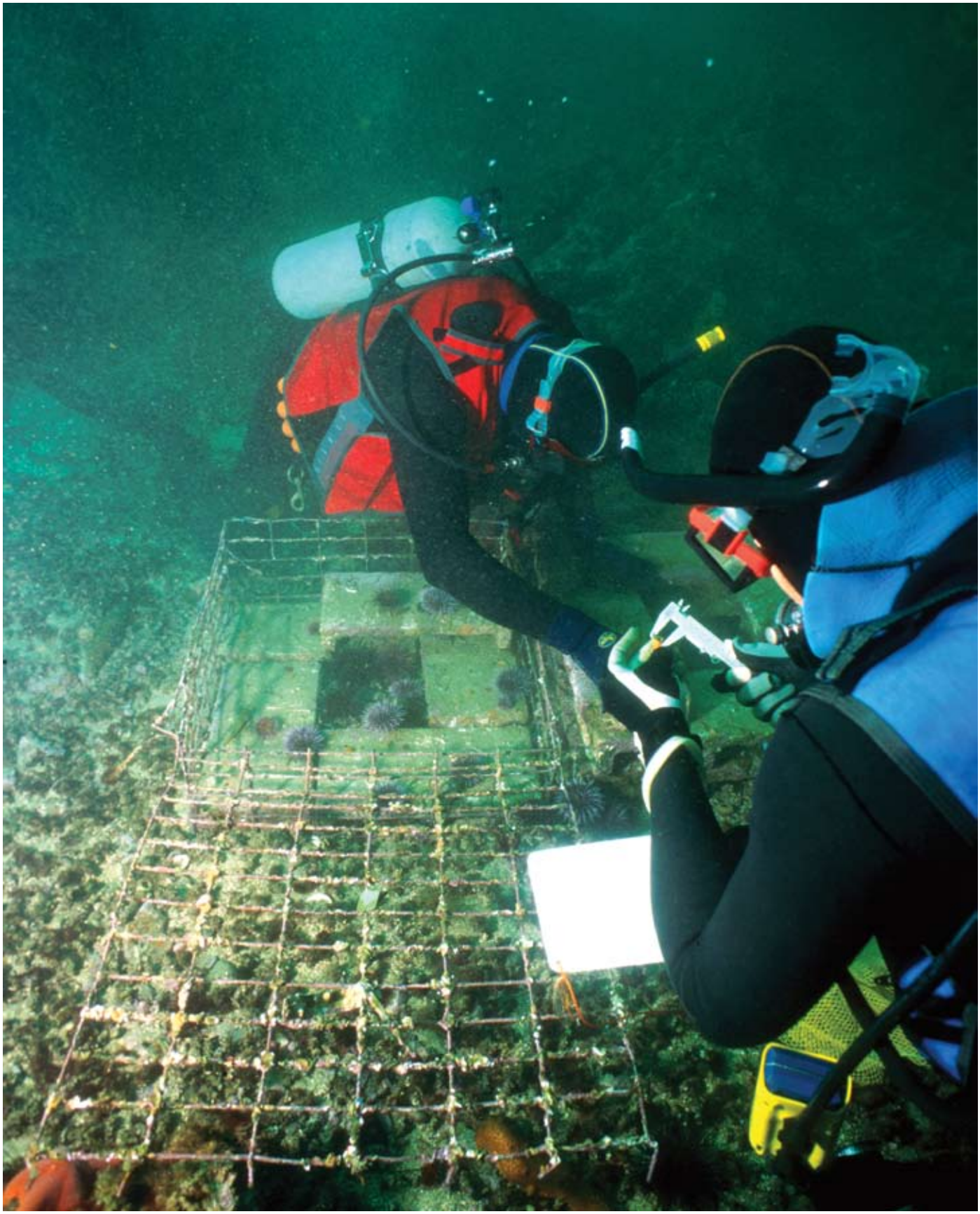


Science divers with the National Park Service monitor the kelp forest at Channel Islands National Park, California. The National Park Service, the NOAA National Marine Sanctuary Program, and the California Department of Fish and Game collaborate on the management of marine reserves in the Channel Islands.

Marine reserves attract scientific scrutiny and funds for research

By Cliff McCreedy

RECENT REPORTS BY THE U.S. COMMISSION ON Ocean Policy and the Pew Oceans Commission have drawn the attention of state and federal policy makers to the beauty, value, and rapid decline of ocean resources. Pollution, overdevelopment, ocean warming, and overfishing are outpacing the ability of resource management agencies, including the National Park Service (NPS), to coordinate science-based solutions to these problems. To combat increasing threats to ocean resources, marine reserves—protected areas in which extractive uses are prohibited entirely or restricted to a few oceanic or other species—have been established in and around five national parks in an effort to restore depleted fish populations. Research and monitoring of the new marine reserves are required to determine their effectiveness. In 2006, marine reserves received helpful scrutiny from participants at an international scientific workshop held at Virgin Islands National Park, where the U.S. Geological Survey (USGS) announced that it will provide funds for research at three of these reserves.

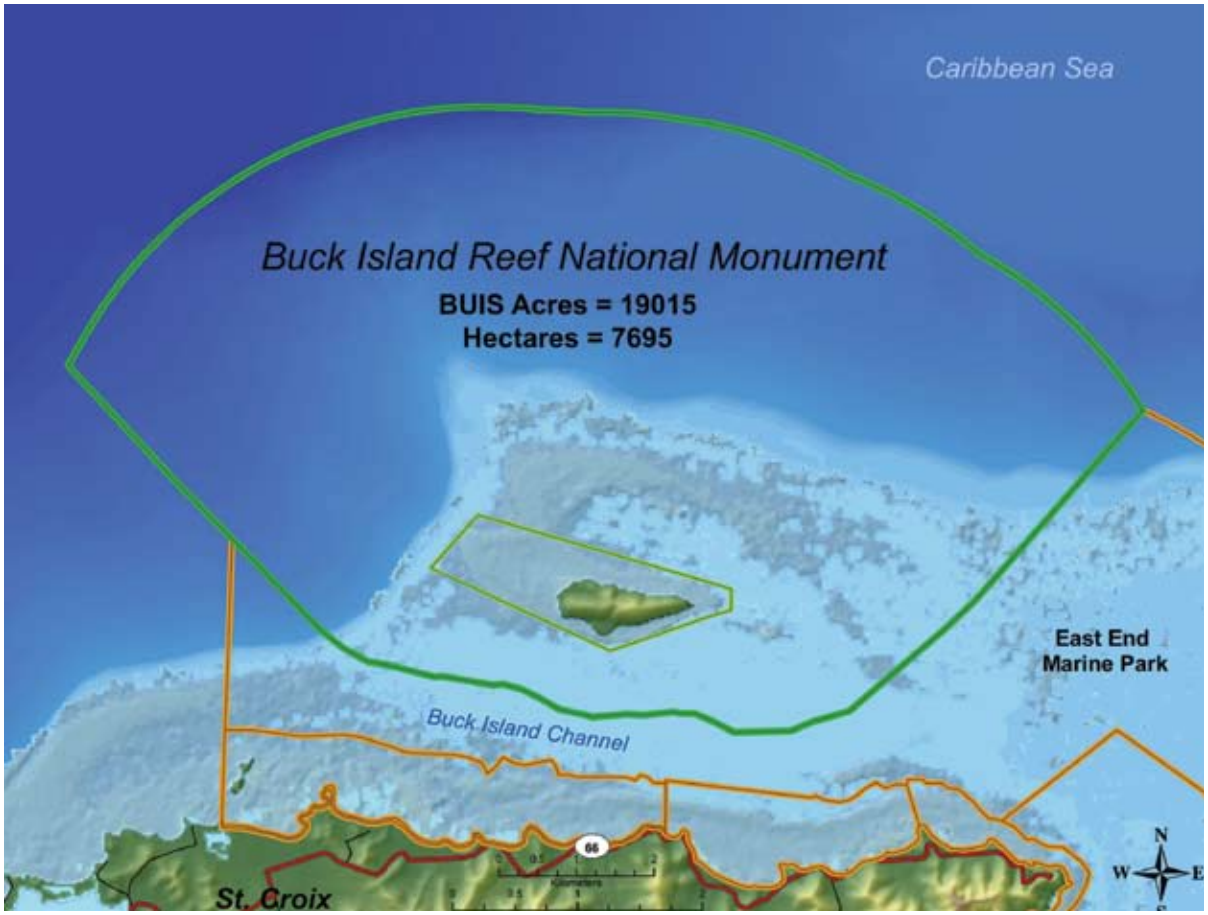
Contrary to public perception, the National Park System is not immune to threats facing the world's oceans. Fishing occurs throughout most ocean parks. Unless specifically prohibited, NPS policies allow recreational fishing consistent with NPS and state fishing regulations and commercial fishing where authorized by enabling statute or regulation. However, these policies have generally failed to maintain fish population sizes and structures capable of ensuring ecosystem health and sustaining recreational fishing opportunities in many ocean parks.

During the past several years, marine reserves have been created in or around five national parks in an effort to reverse negative trends. Most recently, on 14 November 2006, the State of Florida concurred with NPS regulations to establish a research natural area (RNA) at Dry Tortugas National Park (Florida). The new RNA is a no-take, no-anchor zone occupying 46 square miles (119 sq km) of the park that provides a sanctuary for species affected by fishing and loss of habitat. Marine reserves at Buck Island Reef National Monument and Virgin Islands Coral Reef National Monument (both in the U.S. Virgin Islands) share similar objectives. For example, both marine reserves seek to sustain tropical marine ecosystems and to protect fragile coral reefs and seagrass beds, and the marine species they support, from fishing and anchor damage. Marine reserves have also been established at Glacier Bay National Park (Alaska) and Channel Islands National Park (California) in conjunction with the California Department of Fish and Game.

The National Park Service has a clear mandate to employ the best available science to evaluate the performance of these new marine reserves and to adapt its management and monitoring programs according to changes observed in resource condition. In expressing support for the Dry Tortugas National Park RNA, Florida Fish and Wildlife Conservation Commission Chairman Rodney Barreto said, "While we agree with a closure to fishing and its scientific importance, we must also ensure the objectives of a fishing closure are met, and we will monitor this area closely for progress and success."

Programs such as the kelp forest monitoring program at Channel Islands National Park, vital signs monitoring, and the National Oceanic and Atmospheric Administration (NOAA) Biogeographic Assessments of coral reefs, fish, and invertebrates are yielding critical information to meet these adaptive management goals. However, important research and monitoring questions remain. For example, what are expectations for fisheries to rebound in light of pressures from fishing outside these reserves? Will marine reserves help reverse declines and restore ecosystem structure and function in spite of stresses other than fishing, such as coral bleaching and disease?

In July 2006 the NPS Water Resources Division (WRD) and the U.S. Geological Survey held an international workshop in the U.S. Virgin Islands to identify opportunities for future research and monitoring in the new marine reserves. Organizers included Gary Davis and Cliff McCreedy of the WRD Ocean and Coastal Resources Branch, Dr. Caroline Rogers of the USGS Caribbean Field Station, and Dr. Daniel Suman of the Rosenstiel School of Marine and Atmospheric Sciences, University of Miami. In addition to staff from the Virgin Islands national parks and the NPS South Florida/Caribbean Inventory and Monitoring Network, workshop participants included the NOAA Center for Coastal Monitoring and Assessment, the Florida Keys National Marine Sanctuary, and 30 other scientists and managers from the United States,



Map of Buck Island Reef National Monument (St. Croix, U.S. Virgin Islands), where all fishing is prohibited and anchoring is restricted. Marine reserves, or protected areas in which extractive uses are prohibited entirely or restricted to a few species, have been established in and around five national parks over the last several years. Marine reserves like the one found at Buck Island Reef National Monument have been established throughout the world with a variety of goals, usually conservation of biodiversity and enhancement of fisheries.

Mexico, and the Caribbean. Funding was provided by the NPS Office of International Affairs.

The workshop succeeded in establishing goals and specific questions for evaluating the performance of the Dry Tortugas and Virgin Islands marine reserves. Biological goals include understanding, documenting, and projecting changes in marine biodiversity, nutrition dynamics, and population sizes of fish in and around reserves. Engaging local and regional communities in monitoring programs and measuring and incorporating attitudes and perceptions toward fishing closures in research efforts were identified as social goals. The experiences shared by managers and scientists from different countries enriched the dialogue. The workshop report (see reference below) is available online at http://snre.ufl.edu/funding/attachments/Attach%204%20Rogers%20et%20al.%20Marine%20Reserve%20Workshop.pdf.

Perhaps the most valuable outcome of the workshop was that the USGS Eastern Region has agreed to dedicate more than $300,000 annually to support competitive research grants to evaluate the three marine reserves in Florida and the U.S. Virgin Islands. State-supported agencies and academic institutions will apply for the grants, and the July workshop report will guide applicants in structuring research proposals and tailoring approaches to management regimes and resources in these reserves. ■

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"Alaska Stream Team" brings hands-on science study to Sitka National Historical Park and Tongass National Forest

By Lisa Matlock

IT IS APRIL 2006 AND THE INDIAN RIVER IN SITKA, Alaska, is filled with students splashing and scrambling among cold and slippery rocks to collect water, algae, insects, and other samples. These third and seventh grade science students, along with Sheldon Jackson College students working toward resource-related careers, are involved in an educational aquatic monitoring program within Sitka National Historical Park.

In 2004 the National Park Service and the USDA Forest Service worked together with Dan Bogan, a University of Alaska–Anchorage aquatic biologist, to train local educators in the "Alaska Stream Team" water quality inventory and monitoring program. Since that time the national park's education specialist, Lisa Matlock, and biologist Geoffrey Smith have partnered with Jim Case, the education and information technician for the Sitka District of the Tongass National Forest, to bring the Alaska Stream Team program to schools in Sitka.

This program advances the quality of science programming for area students while providing ongoing biological and chemical monitoring of the Indian River.

This program advances the quality of science programming for area students while providing ongoing biological and chemical monitoring of the Indian River. Students sample populations of mayflies, stoneflies, and caddisflies, which are sensitive to environmental changes like increased siltation and pollution, to determine the health of the ecosystem. Chemical testing includes temperature, flow rate, pH levels, and dissolved oxygen content, with samples taken in spring and fall every year. Park and forest educators use three monitoring sites: two in the park's lower reach of the river near the estuary and one upstream just below the forest boundary above human habitation. Between these monitoring sites is city land with growing residential and commercial development that could potentially impact water quality in the river, which is also Sitka's alternate drinking water source.

The USDA Forest Service and the National Park Service use this innovative program to teach Sitka's students about the importance of watershed protection. These agencies manage the upper and lower sections of the Indian River separately, but now work in partnership to manage this resource for the larger benefit of the public through education. The Alaska Stream Team program is a natural outgrowth of the historical connection of the park and forest that harkens back to the 1890s, when Congress set aside the first Alaskan forest reserve to protect watersheds and established Sitka National Historical Park, with the Indian River as the primary resource mentioned in the legislation.

The stream monitoring program in Sitka provides regional benefits as the data collected by the seventh grade and Sheldon Jackson College students are added to the Alaska Stream Team database for larger use by scientists and by other students throughout the state to monitor the general health of Alaska streams. If the data gathered by students suddenly show anomalies unrelated to seasonal or other natural fluctuations, then aquatic biologists are alerted to investigate the situation. The student-gathered data can be an early indicator of stream problems that can be corrected before serious negative effects occur. This is particularly important in a huge state where the number of aquatic biologists is limited and they are unable to monitor every watershed in the region.

Through the Alaska Stream Team program and the hard work of agency staff, students now provide a service to the National Park Service and USDA Forest Service. At the same time, they experience standards-based, hands-on science in an exciting and engaging environment that allows them to connect the importance of protecting their backyard watersheds to their own lives. ■

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(Top) Seventh graders Maddie Stanley, Christopher Bowman, and Claire West sample aquatic insect populations along the Indian River in Sitka National Historical Park. (Bottom) Sheldon Jackson College chemistry students Yee Vue and Tasha Folsom investigate a sample of stream-bottom debris under the supervision of park education specialist Lisa Matlock.

Wildcam Grizzlies: Real-time bear viewing fosters cooperation, collaboration, conservation, and public participation

By Mary McBurney and Diana Maxwell

DURING THE SUMMER OF 2006 (FROM 23 JUNE TO 25 August), nearly 500 hours of live video of brown bears (*Ursus arctos*) from the McNeil River State Game Sanctuary in south-central Alaska were presented for public viewing at the Pratt Museum in Homer, Alaska. As a result of the *Wildcam Grizzlies* Webcam project, 16,000 museum visitors and more than 1.25 million Internet users were able to remotely watch brown bears in real time and interact with an NPS interpreter, who operated the camera from a museum viewing gallery and provided interpretive programs on brown bear behavior and natural history.

The McNeil River State Game Sanctuary is a national natural landmark (NNL) and is located between Lake Clark National Park and Preserve and Katmai National Park. In addition to its NNL status, the McNeil Sanctuary is significant to the National Park Service (NPS) because it shares both a boundary with Katmai and the same population of brown bears. Most of the bears that frequent McNeil River in the summer use Katmai during other times of the year. This movement of bears between Katmai and the sanctuary makes it incumbent on NPS resource managers to promote the well-being of bears at McNeil River as they do in the national parks.

Wildlife viewers watch brown bears at the McNeil River Falls. The Webcam is housed just below the viewing platform.

The *Wildcam Grizzlies* Webcam project has been phenomenally effective in connecting the public with the McNeil/Katmai brown bears and fostering greater collaboration among the National Park Service, the Pratt Museum (a nonprofit partner), and the Alaska Department of Fish and Game. Although the camera is physically located on state land and the video is publicly displayed at the museum, the project has provided managers at Katmai and Lake Clark with a powerful tool for educating people about brown bears and communicating the importance of their conservation and stewardship. It has also allowed the National Park Service to reach out to people who may otherwise never have an opportunity to view brown bears in the wild and to provide them with a live, real-time bear viewing experience.

Wildcam Grizzlies would not have been possible without the participation of National Geographic Media and their partner, RealNetworks. National Geographic Media was a key partner in bringing the project to the Internet. They helped support the cost of physically setting up and maintaining the Webcam and also created the *Wildcam Grizzlies* Web page on their Web site to allow the public to access the live video via the Internet. In addition they hosted a blog where people could post questions and comments. RealNetworks provided critical hardware and software to transmit near-broadcast-quality video over the Internet and hosted the Web site on their server.

Streaming live video from McNeil River to the Pratt Museum and National Geographic Media, the *Wildcam Grizzlies* Web site has created new opportunities for people to interact with national parks and other public lands through virtual visitation. It has also helped build public appreciation for brown bears and promote a constituency to support their conservation by allowing people to watch wild bears in real time via the Internet. Evidence for this can be found at the *Wildcam Grizzlies* blog, hosted by National Geographic, where an online community has developed around

As a result of the Wildcam Grizzlies *Webcam project, 16,000 museum visitors and more than 1.25 million Internet users were able to remotely watch brown bears in real time and interact with an NPS interpreter.*

An attentive brown bear sow attends her three young cubs at the McNeil River State Game Sanctuary and National Natural Landmark.

the McNeil River video feed. The blog provides an open forum for public participation where people interested in wildlife conservation and brown bears can ask questions, exchange information, and share their observations and thoughts with others. Many bloggers have even been moved beyond the blog to become bear advocates by supporting groups such as Friends of McNeil River and the National Parks Conservation Association.

This project exemplifies everything the National Park Service is trying to accomplish through its Education Renaissance and the Centennial Initiative. It has provided an opportunity for a variety of public and private partners to cooperate and collaborate on a project with a shared mission. It has allowed staff at Katmai and Lake Clark to communicate with national and international audiences using state-of-the-art technologies. It has given the public a new way to connect emotionally and intellectually with these national parks, allowing them to develop a virtual sense of stewardship. And finally, it has created a new group of park advocates who can help support these parks in their efforts to protect brown bears and their habitats. ■

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4 Taking Action to Protect and Restore Native Species

Despite their pristine appearance, national park resources can be degraded or incomplete. Certain species and physical resources may need active assistance to overcome nonnative disease, nonnative invasive plant and insect infestations, habitat fragmentation and loss, erosion, and air and water pollution. The job of national park managers is to understand the condition of the resources in their care and, when deteriorating because of human impacts, take appropriate action to ensure resource protection. The decision to act, though informed by science, requires judgment. Managers evaluate the severity and scale of the problem, the likelihood of resources to recover on their own, the potential for loss if no action is taken, and the possibility that a treatment will introduce undesirable side effects. They also consider legislation, feasibility, timing, and cost. A watch-and-see decision may be best in some circumstances. The articles in this chapter, however, detail active approaches to protecting and restoring park resources. They describe strategies for the control of invasive species, the direct restoration of native species and habitat, and the manipulation of natural processes to foster native species recovery. In addition, they discuss the benefits of broadening and uniting conservation efforts to realize efficiencies and greater effectiveness of long-term and complex treatments through shared expertise, expense, and labor. Altogether the articles describe management actions aimed at protecting and restoring native biodiversity, resilience of ecosystems, and the enduring character of the National Park System.

"When the National Park Service began [in 1916], the appearance of nature—of simple beauty—was mistaken for nature itself. Today we know that scenic beauty can mask dying species and disappearing ecosystems." **—Robert G. Stanton**

Uniting efforts to restore eastern brook trout

By Catherine Schmitt

THE BROOK TROUT IS THE ONLY TROUT NATIVE TO the eastern United States, having survived numerous ice ages of the past several million years. Wild brook trout (*Salvelinus fontinalis*) are prized by anglers and valued by resource managers as excellent indicators of watershed health. Today the healthiest, naturally reproducing populations are found in the coldest, cleanest waters, and the loss of this habitat makes their future insecure.

"Brook trout habitat" calls to mind crystal, gurgling streams on lush temperate mountainsides, or the sandy mouths where rivers empty into Great Lakes or salty bays—the same scenes that are common to our national parks. But looks can be deceiving. Even in a national park what appears pristine may actually be degraded or incomplete. Eastern brook trout occupy only about 5% of their historical habitat and the naturally reproducing populations of this species are in decline throughout their native range, which includes 16 units of the National Park System for certain and probably 2 more. Populations have been eliminated or greatly reduced in almost half of the areas that historically supported the species, mostly as a result of land management practices. Competition with introduced species like the European brown trout, barriers such as culverts and dams, and changes in streambank habitat caused by insect infestations, disease, and timber harvest have reduced brook trout numbers. Self-sustaining populations will not come back without active assistance from resource managers and conservationists.

Assessing the status of this species within its natural range, which is along the spine of the Appalachian Mountains and the coastal plain from Maine to Georgia and west to the Great Lakes, is a complex task that involves many organizations and individuals. In the past, national park staffs have cooperated in local assessments and fact-finding exercises to better track and manage fish populations, but not as part of a cohesive or coordinated effort. However, eastern brook trout have emerged as an important focal species, and scientists, managers, anglers, and conservationists are uniting in collaborative, geographically broad initiatives to better understand the species and the efforts needed to restore and protect its habitat. The Eastern Brook Trout Joint Venture is one initiative that has prompted biologists who are already working on brook trout conservation in national parks to join with other governmental and private entities in conservation and management activities. The venture is the first pilot project of the National Fish Habitat Initiative, which was created with congressional, public, and private funds in 2005.

In many national parks participating in the joint venture, biologists have taken a lead role in this partnership, prompting restoration, collaborative protection and management, enhanced information and data exchange, and a better understanding of the regulatory and policy changes needed to protect the species. They are working to address brook trout population and habitat concerns and to elevate the importance of this species as a key component of both small and large ecosystems.

Stanley Brook empties into the Atlantic Ocean in Acadia National Park, Maine. The brook is home to a sea-run population of wild brook trout. The overlay shows a brook trout close up and is not part of the original photo.

In 2006, Bruce Connery, National Park Service biologist at Acadia National Park (Maine), surveyed resource managers at more than 20 units of the National Park System in the eastern United States that host brook trout. Whereas managers at all 11 units that responded have an idea of which streams in their parks have brook trout, only 8 of them have good information about water quality and the status of brook trout populations. "Though this survey has demonstrated the value of collaborative efforts, it also illustrated many gaps in our knowledge and management capabilities for fish and their habitats," according to Connery. "Support through the Eastern Brook Trout Joint Venture and other initiatives could greatly extend and strengthen conservation efforts already under way." All park respondents suggested that more information was needed about fish and their habitats so that long-term conservation strategies and cooperative restoration programs can be implemented.

For example, in Acadia National Park, Connery is working with scientists and managers from various organizations to answer a range of questions about brook trout and their habitat. Partners include the Maine Department of Inland Fisheries and Wildlife, Maine Sea Grant, University of Maine, U.S. Geological Survey Cooperative Fish and Wildlife Research Unit, U.S. Fish and Wildlife Service, and USDA Forest Service. A day of sampling in October 2006 brought out a veritable who's who of fisheries and habitat scientists in the Northeast. Acadia presents a special situation, since some of the brook trout there are sea-run

Staff from the Maine Department of Inland Fisheries and Wildlife and NPS Biologist Bruce Connery (right) sample for sea-run brook trout in Stanley Brook at Acadia National Park in October 2006.

Brook trout have emerged as an important focal species, and scientists, managers, anglers, and conservationists are uniting in collaborative, geographically broad initiatives to better understand the species and the efforts needed to restore and protect its habitat.

populations (sometimes referred to as "salters" or "coasters"), which are even less well understood than their inland counterparts.

Leading the project are Ben Letcher, a fish population ecologist at the Conte Anadromous Fish Laboratory in Turners Falls, Massachusetts, and Joe Zydlewski, of the Maine Cooperative Fish and Wildlife Research Unit. They are looking at the timing of brook trout migration between marine and freshwater environments. Acadia's streams may provide good baseline information on the different life-forms of brook trout, how habitats and genetics may be involved, and what threats exist in both protected and unprotected areas. "For the National Park Service, whose mission is to maintain or perpetuate natural populations and processes to their full integrity," Connery says, "learning about the populations and how they move in these streams and interact with the marine environment will help us understand what is required if we expect to manage and protect these fish and the small streams they inhabit." The Maine researchers also plan to examine the genetics of Acadia's brook trout, an approach that is supported by the Eastern Brook Trout Joint Venture. Only four of the park units Connery surveyed have complete genetics data; those that do are using the information to guide management decisions.

In Lake Superior, biologists with the National Park Service and cooperating agencies created two brood stocks from Isle Royale National Park (Michigan) to rehabilitate coaster brook trout populations at Isle Royale and Pictured Rocks National Lakeshore (Michigan) in the late 1990s. Subsequent monitoring revealed that genetics can vary among streams and trout around the lake. As a result, biologists halted stocking at Pictured Rocks pending further research on genetics and migration patterns, according to Jay Glase, fishery biologist for the Great Lakes national parks. Monitoring population genetics will continue to be part of the ongoing effort to rehabilitate and manage coaster brook trout populations in the Great Lakes.

Though native, genetically distinct brook trout populations can be compromised by stocking of hatchery-raised or nonnative trout, different species can coexist. In Great Smoky Mountains National Park (Tennessee and North Carolina), brook trout are no longer losing range to introduced rainbow and brown trout, according to Steve Moore, lead fisheries biologist. Instead, long-term monitoring has revealed that the native species may be doing better than previously thought. Moore hypothesizes, however, that the apparent tenacity of the species is the result of acidic deposition. Rainbow and brown trout are less tolerant of low stream pH, which may benefit native brook trout populations despite other negative consequences of acidification.

As in Acadia and other national parks, collaborative research and management are aiding the species locally, regionally, and globally. The Eastern Brook Trout Joint Venture has emerged as a model of the kind of grassroots action envisioned in the National Fish Habitat Action Plan; this and similar efforts like the Great Lakes partnership are leading to the realization that collaboration among managers, scientists, landowners, and others results in the greatest chance for success in conserving native species. ■

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Successful bald eagle program highlights the continued recovery of Channel Islands National Park

By Kate Faulkner, Peter Sharpe, and Yvonne Menard

THE U.S. CHANNEL ISLANDS, WHICH ARE HOME to Channel Islands National Park (California), are often called the Galapagos of North America. Never connected to the mainland, the islands are home to many species of animals and plants that are found nowhere else on Earth. However, this amazing oasis of biodiversity was irrevocably altered beginning in the mid-1800s when settlers introduced nonnative livestock. Feral pigs, sheep, rats, and pesticides devastated native plant and animal populations, pushing some species to extinction. Working in cooperation with numerous partners, the National Park Service has undertaken a wide range of efforts in recent years to protect and restore the biodiversity of the Channel Islands. In 2006 a program to restore bald eagles (*Haliaeetus leucocephalus*)—once an important part of the ecosystem—paid off. For the first time in more than 50 years, a bald eagle chick hatched unaided by humans on the Channel Islands.

The bald eagle restoration program was made possible through a partnership among state and federal agencies, including the National Park Service. The partnership was assisted by nongovernmental partners such as the Institute for Wildlife Studies, a nonprofit working for more than 25 years to restore wildlife on the Channel Islands, which carries out the fieldwork for the eagle restoration program.

From 2002 to 2006, biologists imported 61 bald eagle chicks from Alaska and the San Francisco Zoo to Santa Cruz Island, one of five islands that make up Channel Islands National Park. Only four years after starting the restoration program, biologists were surprised in 2006 by two successful bald eagle nests on Santa Cruz Island, each fledging one chick. In 2007 one nest with one chick has been documented and the chick fledged in late June.

In April 2006 the first bald eagle chick in more than 50 years hatched on the Channel Islands. Its radio and satellite transmitters have allowed biologists to track this bird, known as A-49, moving among the islands and visiting the mainland of California. Monitoring efforts have provided essential data on mortality and movements of the birds following fledging and departure from release sites.

Thrilled with public interest in the first chick, now known as A-49 (see photo), Channel Islands National Park, in partnership with the Institute for Wildlife Studies and the Ventura County Office of Education, established a Webcam in 2006 that brought live streaming images of the chick and its parents into the schools and homes of people around the world. The Channel Islands EagleCAM and associated discussion board, which can be found at http://chil.vcoe.org/eagle_cam.htm, developed a devoted following. The discussion board proved to be a fun and easy way to find play-by-play descriptions of the nest action, explore updates from biologists in the field, and get to know other eagle enthusiasts around the world. The project was so engaging that in July 2006 when the first eagle chick fledged at three months of age, EagleCAM devotees held a worldwide virtual toast. Because of the success of the Webcam, it has been reestablished on Santa Cruz Island to watch nesting activity in 2007. Volunteer observers take shifts

For the first time in more than 50 years, a bald eagle chick hatched unaided by humans on the Channel Islands.

throughout the day to document the birds' behavior. The solar-powered camera runs daily between dawn and dusk. Additional park Webcam information and archival footage can be found at http://www.nps.gov/chis/photosmultimedia/webcams.htm.

Bald eagles were once a very important component of the Channel Islands' ecosystem. However, human harassment, collection of eggs, and ultimately the pesticide DDT resulted in the complete extirpation of the species from the islands. Southern California, once the center for manufacture of DDT, trails the rest of the United States in the recovery of bald eagles because high levels of DDT remain in the surrounding marine ecosystem. A successful federal and state lawsuit against manufacturers and distributors of DDT provided the funds to begin the bald eagle restoration program at Channel Islands National Park in 2002.

DDT severely reduced numbers not only of bald eagles but also peregrine falcons (*Falco peregrinus*), California brown pelicans (*Pelecanus occidentalis californicus*), and other seabirds. However, bald eagles, feeding higher on the food chain, have been the slowest to recover. All the bald eagle chicks introduced through this program are outfitted with blue wing tags, a conventional radio transmitter, and a satellite Global Positioning System transmitter. These have provided essential data on mortality and movements of the birds following fledging and departure from release sites. Additionally, movement-activated cameras mounted at bait stations help to detect unmarked birds and birds whose radio transmitters are no longer active.

Reestablishing bald eagles has been part of a larger effort to restore and protect the special ecosystem of the Channel Islands. In recent years the park and partners like The Nature Conservancy, which co-owns Santa Cruz Island with the National Park Service, have eliminated nonnative animals, such as feral pigs, sheep, rats, and cattle. Species once threatened with extinction, like the island foxes, are moving toward recovery. The story of the restoration of the Channel Islands is featured in a recent edition of *The Nature Conservancy* magazine, at http://www.nature.org/magazine/winter2006/features/index.html. Restoring a healthy bald eagle population is a significant part of bringing back the natural productivity and diversity of the Channel Islands.

In order to return the bald eagle to Channel Islands National Park, biologists imported 61 chicks from Alaska and the San Francisco Zoo to Santa Cruz Island from 2002 to 2006. Two juvenile bald eagles exercise their wings and think about taking their first flight from one of two release towers on the island.

The goal of the program is eventually to establish bald eagle nests on all five islands. Many of the birds introduced into the ecosystem are still too young to reproduce. In the next several years, many of these birds will reach maturity and more nesting territories will likely be established. The signs are good that the bald eagle is back to stay on the Channel Islands. ■

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Black-footed ferrets in recovery

By Brian C. Kenner

THE YEAR 2006 MARKED THE 25TH ANNIVERSARY of the night a rancher's dog near Meteetze, Wyoming, killed a strange animal at his food bowl and the world learned that the black-footed ferret (*Mustela nigripes*), believed extinct at the time, still survived in a small, isolated population. That night, Shep unwittingly set in motion one of the most intensive, expensive, and controversial endangered species recovery programs in the history of the Endangered Species Act.

The trials and tribulations of restoring this little-known predator to its former range are well documented. The captive breeding effort, which began with only 18 animals salvaged from the Meteetze population, has produced more than 2,600 animals for restoring black-footed ferrets in several Great Plains states. In South Dakota a self-sustaining wild population of black-footed ferrets has grown and thrived in the Conata Basin/Badlands Recovery Area, which includes parts of Badlands National Park and Buffalo Gap National Grassland. The NPS Natural Resource Preservation Program funded restoration of ferrets to the national park, where a small population remains. Most of their descendants, however, have moved to the adjoining USDA Forest Service grassland. By the end of 2006, at least 200 animals comprised the population in the recovery area, with annual production of around 50 litters of two to four kits. The site has proven so successful that wild-born kits considered excess to the habitat are relocated to other recovery sites in South Dakota. Wind Cave National Park may soon begin reintroduction in part with kits from the Conata Basin/Badlands.

In South Dakota a self-sustaining wild population of black-footed ferrets has grown and thrived in the Conata Basin/Badlands Recovery Area.

In 2003, scientists from the National Zoo made an important discovery about the Conata Basin/Badlands that speaks to the success of this population: The sperm of wild-born males, unlike that of the captive breeding males, did not show signs of genetic mutations due to inbreeding. This discovery makes this wild population very important to the continued genetic viability of the species. Other recovery sites in Wyoming and Montana have had some success, but outbreaks of sylvatic plague and other diseases that destroy prairie dog populations have prevented establishment of other self-sustaining ferret populations.

Because ferrets depend on prairie dogs as their primary prey and live in prairie dog burrows, ferret recovery is directly linked to the viability of prairie dog towns. The four prairie dog species native to the United States occupy less than 1% of their historical range, so potential threats to prairie dog colonies carry significant implications for ferret populations.

One threat faced by prairie dogs results from six years of drought in western South Dakota, which has greatly reduced grass production in the Conata Basin. As prairie dog colonies rapidly expand outward toward remaining grass, often onto private grazing lands, they leave areas nearly devoid of vegetation. Ranchers become less tolerant of encroaching prairie dogs as year after year of below-normal precipitation reduces available grass. Thus the State of South Dakota, the USDA Forest Service, and the National Park Service have all been developing prairie dog management

Veterinarian JoGayle Howard and geneticist Samantha Wisely of the National Zoo in Washington, DC, collect sperm from an anesthetized Conata Basin/Badlands ferret. Analysis revealed that the sperm of wild-born males, unlike that of the captive breeding males, did not show signs of genetic mutations, which can be caused by inbreeding.

Black-footed ferret, Badlands National Park, South Dakota.

plans. The USDA Forest Service, whose plan calls for a quarter-mile prairie dog–free buffer zone between the grassland population and private land, is also considering control measures in the interior of the grassland.

A second threat emerged in 2005 when a large prairie dog colony on the Pine Ridge Indian Reservation adjacent to Badlands National Park was nearly depopulated by sylvatic plague. This colony's proximity to the Conata Basin triggered an interagency effort to document the extent of the disease and monitor progress toward the Conata Basin/Badlands colony. In 2005 and 2006 the NPS Wildlife Health Team, based in Fort Collins, Colorado, joined staffs of Badlands National Park and other federal and state agencies to conduct extensive dusting around prairie dog burrows in Conata Basin to eliminate plague-carrying fleas while the U.S. Geological Survey began researching plague vaccines for prairie dogs. In December 2005, Badlands biologists, working with area coyote hunters, found one plague-positive coyote on the edge of the Conata Basin. The National Park Service, USDA Forest Service, and State of South Dakota are working to develop a contingency plan for saving Conata Basin/Badlands ferrets if an outbreak of plague occurs.

The restoration of black-footed ferrets to Conata Basin/Badlands by the National Park Service and USDA Forest Service has been one of the most important aspects of the species' recovery. One of the lessons learned from this work is that after the initial excitement of the project has passed, agencies are faced with the need for continual monitoring and response to threats that require ongoing financial commitment and dedication of staff. The saga of black-footed ferrets continues, and though much progress has been made in the 25 years since Shep's discovery, the chapter in which the species is secure has yet to be written. ■

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Recovery efforts increase piping plover population at Sleeping Bear Dunes National Lakeshore

By Zoé Lebrun-Southcott and Alice Van Zoeren

Data collected from the long-term banding program at Sleeping Bear Dunes show that the 12-year-old BO:RX has had a large impact on the genetics of the Great Lakes piping plover population.

BO:RX IS BACK! THE NEWS traveled quickly among the staff at Sleeping Bear Dunes National Lakeshore (Michigan) on 11 April 2006. BO:RX is the code for the band combination of a well-known, 12-year-old male piping plover nesting at Sleeping Bear Dunes since 1997. His arrival signaled the 2006 piping plover monitoring and protection season at the lakeshore.

In 1986, with only 17 breeding pairs counted, the Great Lakes population of piping plovers was listed as endangered under the U.S. Endangered Species Act. Sleeping Bear Dunes National Lakeshore, along with several partnering organizations, initiated an extensive recovery effort at that time. Although the population of Great Lakes piping plovers is steadily increasing, it remains well below the recovery goal of at least 150 pairs by 2020. Until the population is large enough to sustain losses from natural predators, beach changes, habitat degradation, devastating storms, development, and recreation, managers will continue to take action on behalf of the piping plovers.

In 2006, final tallies showed that Sleeping Bear Dunes was home to a large percentage of the nesting Great Lakes piping plovers. Of the 53 pairs counted, 20 were located at Sleeping Bear Dunes. Forty-four of the 94 chicks fledged were from the national lakeshore. These numbers illustrate the paramount importance of the national park program to the recovery of the Great Lakes population of piping plovers. Other national lakeshores, including Indiana Dunes, Pictured Rocks, and Apostle Islands, are participating in the piping plover recovery efforts. Although no new nests were confirmed at Indiana Dunes or Pictured Rocks in 2006, Apostle Islands protected four nests.

Working in cooperation with staff from other agencies and many dedicated volunteers, National Park Service (NPS) staff and interns monitor and protect the nesting piping plovers at Sleeping Bear Dunes and throughout the region, with the goal of increasing the chances for reproductive success.

Protection activities include surveying shorelines for nesting plovers, establishing rope fencing around potential nesting areas, erecting exclosures (small fenced areas that keep out predators) around nests, and daily monitoring until the chicks fledge. In addition, chicks and adults are banded with a distinctive color combination that allows staff to document their behavior; determine fledging success; and track population genetics, migrations, habitat use, and behavior.

To bolster the population, eggs salvaged from abandoned nests are raised at the University of Michigan Biological Station by volunteer zookeepers from around the nation. In 2006, 8 of the 17 captive-reared chicks released back into the wild came from nests at Sleeping Bear Dunes.

One of the primary obstacles to the recovery of this population is predation. Evidence suggests that predation increases as nesting density increases; hence recovery efforts may face escalating losses from predation as the population recovers. A predator control program for gulls and crows is being piloted within the lakeshore on North Manitou Island in conjunction with the U.S. Department of Agriculture, Wildlife Services; the Michigan Department of Natural Resources; and the U.S. Fish and Wildlife Service.

A high percentage of chicks disappear in the first 10 days after hatching. Research into the causes of this mortality will help managers decide how best to protect the population of piping plovers.

So far the results are promising. Since the program started in 2003, the number of chicks that have fledged on North Manitou Island has increased each year, to a record 31 in 2006. As the population of piping plovers increases, however, questions arise regarding the intensity of predator control that may be required to maintain such successful fledging rates in the future. Managers will be faced with difficult decisions as the survival of an endangered shorebird clashes with the natural predatory actions of other species that share its habitat. This issue is further complicated because human activities have allowed for populations of some predators to become unnaturally high.

Crowded nesting conditions, due to increased nest density, could enhance chick protection as piping plovers engage in communal parenting. In addition, chicks may fledge earlier in dense colonies, thereby reducing their vulnerability to predators.

As the population recovers and the number of nesting pairs increases at Sleeping Bear Dunes and throughout the Great Lakes region, the birds will disperse into other areas of suitable habitat. When this occurs, the population will be more widely distributed and hence more stable. Suitable habitat, therefore, even if it is not currently occupied by the recovering population, must be maintained and protected to increase the overall population of piping plovers. ■

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Managers will be faced with difficult decisions as the survival of an endangered shorebird clashes with the natural predatory actions of other species that share its habitat.

Controlling honeysuckle to restore woodcock habitat

By Constance A. Ranson and James Anderson

AT THE TIME OF THE FIRST BATTLE OF THE FRENCH and Indian War (3 July 1754), Fort Necessity was situated in western Pennsylvania's native climax forest. Today, at Fort Necessity National Battlefield, natural resource managers are working to restore the historical landscape in the face of an aggressive invasion of Morrow's honeysuckle (*Lonicera morrowi*), an exotic shrub introduced from Japan around 1875. It dominates the hillsides surrounding the Great Meadows and is invading wetland and dry meadows adjacent to the fort. The honeysuckle is inhibiting forest regeneration, leading to an increase in nesting predation of shrubland birds and a decrease in native plant and animal diversity. Located southwest of the fort and at a slightly higher elevation are approximately 25 acres (10 ha) of honeysuckle-dominated habitat used in spring as a singing and display area by the American woodcock (*Scolopax minor*), a shrubland bird species whose population is in decline. Park management and partners are interested in conserving and enhancing this area as woodcock breeding habitat.

To understand the current ecosystem of the woodcock habitat and plan the restoration of the area, national park staff competed for $106,000 in FY 2003–2006 funding from the Department of the Interior's Cooperative Conservation Initiative. The funds were appropriated for the purpose of (1) documenting the distribution of plant communities dominated by the exotic honeysuckle within the woodcock breeding habitat; (2) providing a baseline data set of animal and plant communities occupying the honeysuckle, emphasizing woodcock population size; (3) developing and testing honeysuckle control strategies (e.g., mechanical, chemical); and (4) developing a habitat management plan to promote woodcock habitat and control honeysuckle. The work was undertaken by a team from West Virginia University, a member of the Great Lakes/Northern Forest Cooperative Ecosystem Studies Unit, and staff at Fort Necessity National Battlefield. The research was completed and the findings were published by West Virginia University in 2006 in a report titled "Management Plan for a Degraded Meadow Infested with Morrow's Honeysuckle."

The American woodcock is a species of management concern at Fort Necessity National Battlefield because of loss of breeding and nesting habitat.

The comprehensive survey of the woodcock habitat resulted in the discovery of species of concern not formerly known in the park, including two plants (adderstongue fern [*Ophioglossum vulgatum*] and slender wheatgrass [*Elymus trachycaulus*]) and two birds (prairie warbler [*Dendroica discolor*] and golden-winged warbler [*Vermivora chrysoptera*]).

To determine the most efficient method of honeysuckle control, the investigators established test plots where honeysuckle was mechanically removed or treated with herbicide, and compared efficacy, labor required, and cost of different methods. They also analyzed the total nonstructural carbohydrate in honeysuckle roots sampled every month for one year and found that it was lowest in the roots by the end of May, immediately after leaf-out and flowering, and highest in the roots in October, a finding shared with the Northeast Region Exotic Plant Management Team. Test plots revealed a reduction in native woody plants, possibly due to herbicide affecting nontarget species and increased deer herbivory on natives after the honeysuckle was removed. The resulting honeysuckle management plan for 2007 will involve mowing in the spring by park staff and herbicide treatment in the fall by a contractor. Native plants will be purchased, as well as "borrowed" from other areas within the park, and planted within the treatment area. Monitoring flora and fauna within woodcock habitat and control areas, both before and after treatment, will continue to be a partnership effort between park managers and West Virginia University.

Honeysuckle is inhibiting forest regeneration, leading to an increase in nesting predation of shrubland birds and a decrease in native plant and animal diversity.

This project has involved not only partnering with West Virginia University and the Great Lakes/ Northern Forest Cooperative Ecosystem Studies Unit, but also other federal agencies (USDA Forest Service, U.S. Fish and Wildlife Service), park neighbors, local schools, county conservation districts and watershed groups, private organizations, and private landowners, all of whom have voiced an interest in forming a cooperative weed management area to address the local and regional problem of exotic plants and the need for education, information, and resource sharing. A cooperative weed management area is a local organization that integrates all invasive plant management resources across jurisdictional boundaries in order to benefit entire communities.

Exotic vegetation control is the initial step in restoring the Great Meadows to the diverse native habitat that existed there around 1754, and in restoring American woodcock habitat. Restoration of the native habitat and cultural landscape is most likely to succeed through the cooperative efforts of the parks and partners in researching and implementing the best methods to protect and enhance these habitats for both biological value and historical ambience. The information obtained from this project can be globally applied to other habitat restoration projects where control of exotic vegetation must be the first step. ■

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Morrow's honeysuckle is an invasive plant species that has infested American woodcock habitat at Fort Necessity National Battlefield in dense thickets (top). A multiyear resource management research project culminated in 2006 in a plan for the removal of honeysuckle vegetation by mechanical means (bottom) and herbicide treatments.

Control of nonnative plant invasions through efficient partnerships at Assateague Island National Seashore

By Ron Dean and Jonathan Chase

SUCCESSFUL COLLABORATIVE PARTNERSHIPS HAVE augmented the National Park Service's (NPS) management of invasive nonnative plant species at Assateague Island National Seashore (Maryland) and adjacent lands. In 1999, park staff began managing invasive nonnative plant species and to date has met the challenge of limiting their expansion with remarkable success. However, being unable to handle large infestations of invasive plant species alone, park managers requested the assistance of the NPS Exotic Plant Management Team (EPMT) program in 2005 to help restore large areas of degraded habitat.

Assateague Island National Seashore is administered by the NPS Northeast Region, which operates an EPMT. However, the park is nearer and more easily served by the National Capital Region EPMT. This circumstance has given the park and the regional EPMTs the opportunity to approach the work collectively and to share resources. In 2005 the Northeast Region EPMT worked with park staff to treat several populations of invasive plants, including African weeping love-grass (*Eragrostis curvula*), multiflora rose (*Rosa multiflora*), and the prolific clonal tree-of-heaven (*Ailanthus altissima*). In 2006 the National Capital Region EPMT re-treated populations of weeping love-grass and began new control treatments of Japanese black pine (*Pinus thunbergiana*), Japanese honeysuckle (*Lonicera japonica*), and white paper mulberry (*Morus alba*).

This intra-agency partnership has been very successful. Though managers do not expect to eradicate all invasive plant species from the national seashore, this partnership enabled the National Park Service to bring 13 of 15 targeted species down to manageable levels by

Known to occur on Assateague Island National Seashore since the 1960s, African weeping love-grass (before and after treatment; left, top to bottom) gradually escaped from roadside corridors into natural areas where over time it was able to establish dense colonies, making it a prime target for eradication. Control crews cut the tussocks in late spring 2005; new growth was treated with an herbicide and follow-up treatments have helped ensure continued reduction. In 2006, plants treated included Japanese black pine (before and after, right, top to bottom) and other invasive species.

This partnership enabled the National Park Service to bring 13 of 15 targeted species down to manageable levels by 2006.

2006. Quantitative monitoring of treated infestations supports this observation and indicates a steady decline in the number of populations and total area infested by nonnative plants.

Another success has been the establishment of a similar partnership among the National Park Service; the U.S. Fish and Wildlife Service, which operates adjacent Chincoteague National Wildlife Refuge; and the Maryland Department of Natural Resources, which manages neighboring Assateague Island State Park. The National Park Service has helped guide, and joined in, the control of invasive nonnative plant species within those jurisdictions. This assistance has led to the formation of a cooperative weed management area in which all participating land management agencies benefit from coordinated monitoring and treatment efforts. The partners anticipate continued success.

Assateague Island is a barrier island located along the coasts of Maryland and Virginia that encompasses some 48,000 acres (19,440 ha) of aquatic and terrestrial coastal habitats. The ever-growing pressures of development on the East Coast have made this national seashore an increasingly important refuge for many sensitive and rare plant and animal species that are part of distinctive coastal communities. At Assateague, as elsewhere, invasive nonnative plants frequently outcompete native species. They disrupt natural ecosystems by rapidly occupying expansive areas, preventing native communities from recovering from disturbance.

Invasive nonnative plant species are implicated in the listing of 35%–46% of all U.S. threatened and endangered species (Alonso et al. 2001). These invaders have also contributed to the continued decline of more than 40% of listed native species (Ecological Society of America 2004) and are considered the second greatest threat to biodiversity after habitat loss (National Invasive Species Council 2004). Observing no jurisdictional boundaries, invasive nonnative plants are often spread by wildlife and human activity. Moreover, once established, they may be extremely difficult to eradicate. Coordinated cooperative efforts among land management agencies are frequently necessary to effectively combat the threats they pose.

Both intra- and interagency partnerships have facilitated the sharing of knowledge and resources and increased the efficiency of invasive nonnative plant management in and around Assateague Island National Seashore. This approach is helping to preserve and protect our natural heritage and is an example of effective management of nonnative species invasions on a landscape scale. ■

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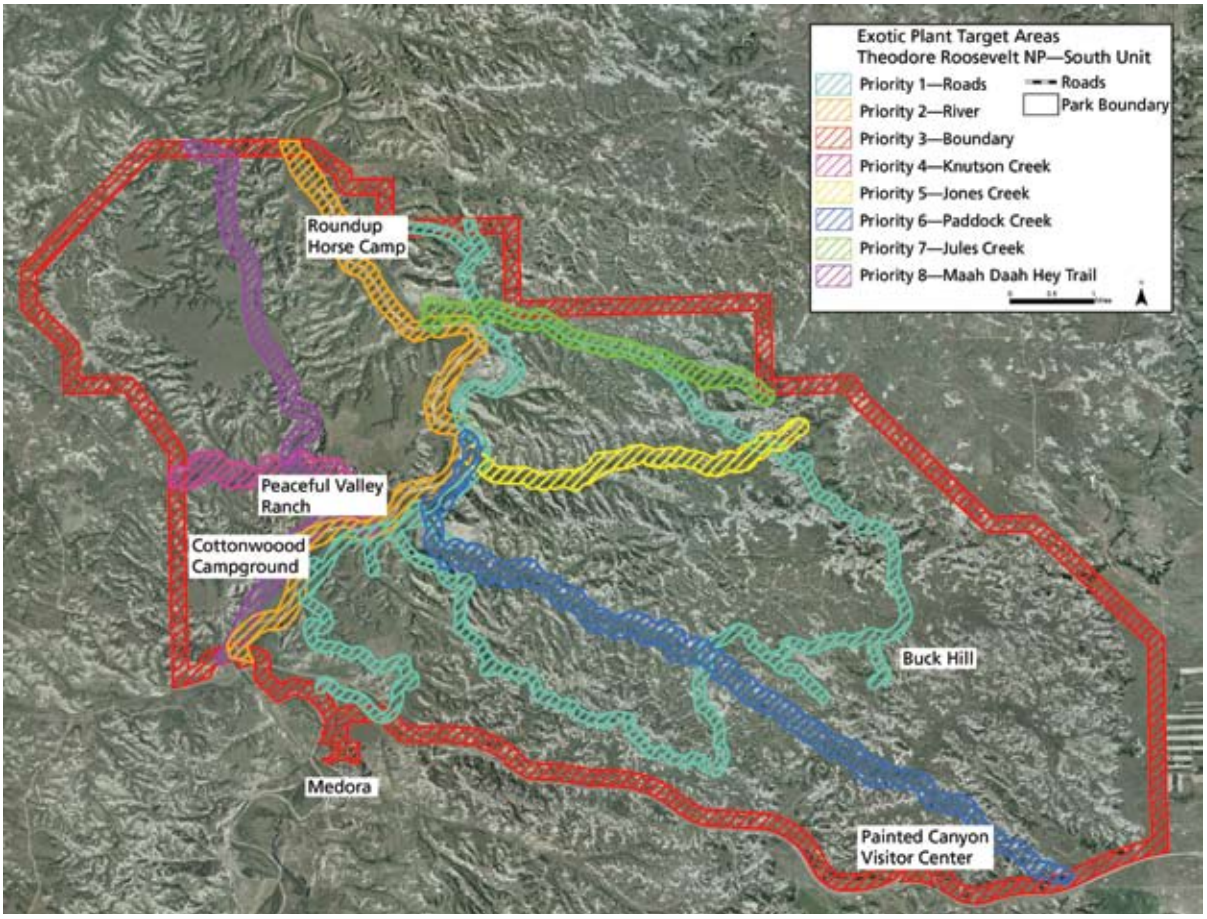
Northern Great Plains Exotic Plant Management Team treats record number of acres in 2006

By Taryn N. Flesjer and Chad W. Prosser

THE NORTHERN GREAT PLAINS EXOTIC PLANT Management Team set a new season record in 2006 by treating nearly 4,000 acres (1,620 ha) among 14 National Park System units in Wyoming, North Dakota, South Dakota, and Nebraska. Since its establishment in 2002, the team has treated nearly 13,000 acres (5,265 ha) in accordance with multiple goals related to controlling the spread of invasive nonnative species and restoring native plant communities.

Based at Theodore Roosevelt National Park, the Northern Great Plains Exotic Plant Management Team includes three satellite units, with personnel stationed at Theodore Roosevelt, Wind Cave, and Badlands national parks. Separation of the units allows the team to work within several parks simultaneously, thus saving substantial time and travel costs.

Over the past five years the team has gained on-the-ground experience and logistical knowledge that, combined with annual training and refinements to standard operating procedures, contribute to ultimate efficiency and cost-effectiveness. All equipment is calibrated and in good condition at all times so the team can apply control treatments to nonnative plants almost immediately upon arrival at a park, stopping the spread of weeds in priority areas along roads, trails, railroads, canals, and streams. The team uses prevention and herbicide along with mechanical and biological control methods as part of an integrated pest management approach to control the spread of exotic invasive plants. Because of the success of this approach, the Northern Great Plains Exotic Plant Management Team and its Environmental Assessment received a finding of "No Significant Impact," signed by the Midwest and Intermountain regional directors in September 2005.



Prioritized treatment areas at Theodore Roosevelt National Park concentrate on areas of high visitor use and high probability of spread of exotic plants along roads, trails, boundaries, and streams.

Each exotic plant infestation presents different challenges and potential solutions, so the Northern Great Plains Exotic Plant Management Team must carefully select the most efficient treatment method in each of 14 park units. They include (right, top to bottom) manual control, biological controls (beetles), and application of herbicide by backpack sprayer, helicopter, and all-terrain vehicle.

The team employs a variety of application techniques. At many parks the team applies herbicide using backpack sprayers or sprayers mounted on all-terrain vehicles. Aerial treatment or horseback patrols control leafy spurge and Canada thistle at other parks. Partners such as the Montana Conservation Corps help with exotic plant removal at some parks. The team also works on several native plant restoration projects at various parks.

In 2006 a significant project eliminated Russian olive and salt cedar trees in two parks. Team members met for eight days to finish cutting and treating these trees in the parks, resulting in the removal of 1,972 Russian olives and 256 salt cedars at Scotts Bluff National Monument and 1,370 Russian olives and 198 salt cedars at Fort Laramie National Historic Site. Continued monitoring by the team and parks will be needed to control any regrowth that occurs.

In the parks that have been treated each of the five years the team has existed, a significant decrease in exotic plant patch size and density has been achieved as well as an increase in recovery of native species. At Devils Tower National Monument, one area formerly blanketed with yellow leafy spurge has been decreased to several smaller, less dense patches noticeable only when one walks through them. Other smaller infestations have been completely eliminated.

In addition to the ongoing work of controlling exotic plants, the team conducts several outreach programs. They present their accomplishments and activities annually to personnel from partner parks, host parks, the Midwest Regional Office, and the Washington Office. The team has been invited to speak at various state Weed Control Association meetings and has been featured in several local newspapers and National Park Service newsletters.

Since 2002 the team has received exceptional assistance in the field and the office from the parks it serves. The Northern Great Plains Exotic Plant Management Team's accomplishments to date are a testament to strong support from parks and partners alike. ■

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Fighting cheatgrass and restoring fire regimes at Zion National Park

By Kelly Fuhrmann

DRASTIC TIMES CALL FOR DRASTIC MEASURES. The spread of cheatgrass (*Bromus tectorum*) across the western United States has become an epidemic that has changed ecosystems on a landscape scale, altering vegetation communities and fire regimes. Hence, after the largest wildfire in Zion National Park's (Utah) recorded history, the National Park Service (NPS), custodian of the public land management preservation and protection mandate, made an uncharacteristic decision to apply on a large-scale an aerial herbicide in order to combat likely infestation of cheatgrass. In many cases the cost of restoring plant communities on a large scale and the timeliness of restoration actions prohibit the implementation of critical restoration decisions. Fortunately Zion National Park had the support of the national Burned Area Emergency Response (BAER) Program, which provided the initial assessment of fire impacts and the financial support for emergency landscape-scale stabilization and rehabilitation.

The primary concern after the Kolob fire was the dominance of cheatgrass, which increases in abundance and density after fire.

In June 2006 the human-caused Kolob fire burned 10,516 acres (4,259 ha) in Zion and 17,632 acres (7,141 ha) total. This fire altered the landscape on an unprecedented scale, resulting in the loss of native vegetation, with probable replacement by nonnative species. Preliminary results from a collaborative U.S. Geological Survey–NPS research project, initiated in Zion Canyon in 2005 and funded by the Joint Fire Science Program, suggested that the use of herbicide to combat nonnative annual grasses and forbs is most successful if it is applied during the fall season after a fire disturbance where the herbicide can reach the soil surface directly. Post–Kolob fire restoration was the perfect opportunity to expand upon the Zion Canyon research project and try the herbicide application on a larger scale. However, park staff had less than two months to complete the compliance and contracting processes and apply the treatment to get the most effective results. Working with the BAER Team of professional hydrologists, soil scientists, and biologists provided the means to meet the time constraint and reach the goal of encouraging native perennial plant reestablishment in areas that are being threatened by cheatgrass invasion.

The primary concern after the Kolob fire was the dominance of cheatgrass, which increases in abundance and density after fire, resulting in increased fuel loads. This in turn promotes a plant community prone to frequent fires. Cheatgrass displaces native grasses and herbaceous plants because, as a winter annual, it is able to establish earlier in the growing season, thus increasing competition and depleting soil moisture. Native plants are eventually crowded out. As cheatgrass continues to increase after each fire, the time between fires becomes shorter. Because native shrubs and trees are slower to reestablish after fire, the increased fires fueled by cheatgrass eventually eliminate most of them from the landscape. With cheatgrass dominance, wildfires tend to occur earlier in the season when native perennials are more susceptible to injury by burning. The result is a conversion from native shrub and perennial grasslands to annual grasslands adapted to frequent fires. This adaptation to and promotion of frequent fires is what gives cheatgrass its greatest competitive advantage in ecosystems that evolved with less frequent fires. Cheatgrass fuels fire, and fire in turn promotes the increased growth of cheatgrass.

To combat the expected cheatgrass invasion, park resource managers chose a restoration approach that included the use of Plateau® over the extent of the burned area in the park. The U.S. Environmental Protection Agency has thoroughly tested this herbicide and approved it for use. Plateau® is highly selective, targeting many of Zion's invasive, nonnative species such as cheatgrass, ripgut brome (*Bromus diandrus*), annual mustards (*Brassica L.*), puncture vine (*Tribulus terrestris*), and field bindweed (*Convolvulus arvensis L.*). In addition, the active ingredient in the herbicide is nontoxic to a wide range of nontarget organisms, including mammals, birds, fish, aquatic invertebrates, and insects; does not bioaccumulate; and has limited mobility in soil. Park staff also applied a mix of native grasses and forbs over 500 acres (200 ha) of the burned area, which before the fire was heavily infested with cheatgrass. This mix consisted of bottlebrush squirreltail (*Elymus elymoides*), sand dropseed (*Sporobolus cryptandrus*), scarlet globemallow (*Sphaeralcea coccinea*), and Palmer penstemon (*Penstemon palmeri*).

Cheatgrass expansion has dramatically changed fire cycles and plant and animal communities over vast areas of the West by creating an environment where fires are easily ignited, spread rapidly, cover large areas, and occur frequently. The Kolob fire burned rugged lands in and adjacent to Zion National Park over four days in June and July 2006. The intensely hot, human-caused fire quickly consumed old-growth piñon-juniper forest and caused concern for the recovery of native vegetation.

Rehabilitation of the fire area incorporated an aerial herbicide treatment and native seeding application, which was the largest undertaking of its kind in NPS history. Contracted helicopter pilots carried out the applications during a two-week period in October and November 2006; they sprayed approximately 9,000 acres (3,050 ha) in Zion National Park.

These species are all native to Zion National Park and are not affected by the herbicide.

Though the decision to launch a massive restoration effort was based on scientific findings, such an unprecedented action requires follow-up to ensure that the chosen methods have been effective. Zion National Park staff has teamed up with the Northern Arizona University School of Forestry in establishing a network of plots throughout the restoration site in order to track changes in vegetation community composition. As park employees look forward to results from the first year of monitoring, anticipation is high for the potential of such actions to inform decisions on restoration in other western landscapes. Sharing lessons learned with the larger land management community will strengthen the National Park Service's ability to detect trends, understand ecosystem processes, and make innovative decisions in the West. ■

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Partnering for resource protection in Redwood National and State Parks

By Darci Short

HOME TO THE WORLD'S LARGEST TREES, REDWOOD National and State Parks (California) harbor ancient, old-growth redwoods (*Sequoia sempervirens*) and habitat for federally threatened coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*O. tshawytscha*), steelhead trout (*O. mykiss*), and other wildlife species. The parks comprising Redwood National and State Parks were established to protect the world-renowned redwoods, which grow on the alluvial terraces and floodplain along Redwood Creek, and the aquatic and terrestrial species dependent on this ecosystem. However, the ability to restore ecosystems impacted by past and ongoing logging requires partnerships with adjacent and upstream private landowners. Reducing sediment threats caused by logging in the upper watershed helps protect resources downstream where the parks are located.

In 1978, the Congress expanded Redwood National Park to protect significant resources from impacts associated with ongoing logging operations occurring adjacent to and upstream from the park. The newly acquired land included more than 38,000 acres (15,390 ha) that had previously been commercially logged. The park expansion legislation also authorized implementation of an erosion prevention program on private lands upstream of the park in the Redwood Creek watershed. Since then, park staff and private landowners have developed a collaborative relationship regarding erosion control and signed formal agreements to "voluntarily cooperate to identify, prioritize, and correct … potential sediment sources within the Redwood Creek basin."

In 2006 the National Park Service completed a two-year partnership project with the Pacific Coast Fish, Wildlife, and Wetlands Restoration Association, a local nonprofit, and Green Diamond Resources Company, an adjacent industrial timberland owner, to reduce sediment threats from a network of roads that crossed both park and private lands in the Coyote Creek basin. This basin, located at the southeastern edge of the parks, is a 5,000-acre (2,025 ha) tributary area of the Redwood Creek watershed that had been used for timber production and ranching. The National Park Service manages about 40% of Coyote Creek, with the remainder held in private ownership.

During restoration of Coyote Creek basin, the National Park Service and its cooperators installed new, larger-diameter culverts at stream crossings. The old culvert at this crossing was severely rusted and substantially undersized for even moderate winter storm flows. The new culvert is 60 inches (150 cm) in diameter, which is large enough to accommodate a 100-year flood.

Before this partnership project, 36 miles (35 km) of roads crisscrossed the Coyote Creek watershed, half of them within Redwood National Park. Many of the roads were abandoned and needed to be removed (decommissioned) to prevent erosion. Other roads were still being used but needed intensive maintenance to prevent future failures that could damage resources.

During the project, park staff and partners treated 8 miles (13 km) of road, about 6 miles (10 km) of which were decommissioned and on private lands. These roads, located on unstable slopes, were posed to deliver a significant volume of sediment to Coyote Creek during heavy rainfall, accompanied by impacts on listed salmonid species. Assessments of the roads revealed

Reducing sediment threats caused by logging in the upper watershed helps protect resources downstream where the parks are located.

that treatment would prevent more than 48,000 cubic yards (36,720 cu m) of sediment from washing into the streams. On national park lands, an additional 1 mile (1.6 km) of road was decommissioned, and 1.5 miles (2.4 km) were upgraded as part of the Lyons Ranches Rural Historic District. Road upgrades included replacing undersized and failing culverts and improving road-surface drainage. These improvements will protect the integrity of the upgraded roads as valued cultural resources in the historic district, which is eligible for listing on the National Register of Historic Places.

The California Salmonid Restoration Grant Program supplied $458,000 to the project, and the Green Diamond Resource Company added $175,000. Park staff provided restoration expertise and project oversight on the portion of the project within Redwood National and State Parks. The Pacific Coast Fish, Wildlife, and Wetlands Restoration Association managed the project. This nonprofit group has also received grants to decommission other privately owned roads within the Coyote Creek watershed and expects to complete this other work in 2008. The National Park Service is pursuing funding to remove 1 mile (1.6 km) of logging road constructed in 1989 that cuts across prairies and oak woodlands in the heart of the historic district. Treatment of this road would complete nearly all erosion control necessary for restoring the Coyote Creek watershed.

The Coyote Creek project demonstrates the value of partnerships in the stewardship of natural resources. Such collaboration is of mutual benefit to diverse stakeholders. In this case a nonprofit restoration group furthered its mission of restoring the north coast region to benefit the declining fishing industry, an industrial timber company leveraged funds to remove unneeded roads from its property and better protect its landholdings, and the National Park Service protected resources in the public trust from external threats. ■

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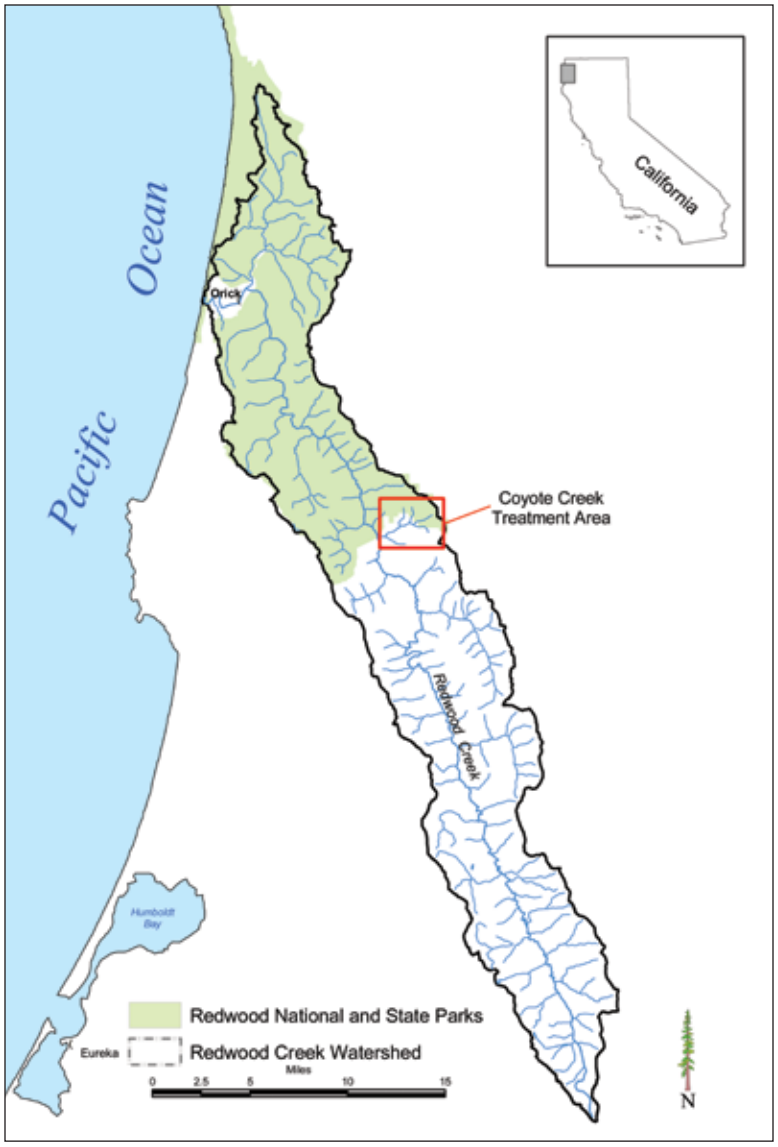

The National Park Service manages about 40% of the Coyote Creek basin, a 5,000-acre (2,025 ha) tributary area of the Redwood Creek watershed. The entire watershed has been used for timber production and ranching. In 2006 the National Park Service; the Pacific Coast Fish, Wildlife, and Wetlands Restoration Association; and Green Diamond Resources Company worked together to restore this watershed.

A cleansing on the Missouri River

By George Berndt

EARLY IN 2007 AN UNUSUAL LANDMARK disappeared from the middle of the Missouri River between Ponca, Nebraska, and Elk Point, South Dakota. For 75 years the 45-foot-tall (14 m) concrete pier (photo) stood sentinel with its partner on the Nebraska bank, part of the support system for a natural gas pipeline built in 1932 by the Northern Natural Gas and Pipe Line Company. Construction predated the establishment of Nebraska's Ponca State Park by two years, with the original piers built on opposite banks. For about two decades thereafter, park visitors viewed with amazement the world's largest pipeline bridge. By 1950 the river's natural flow ate away at the South Dakota bank, leaving that pier in the middle of the river. As a safety precaution the company dismantled the pipeline and the towers, but the piers remained.

The story of the mid-channel pier became more complicated when Congress amended the National Wild and Scenic Rivers Act in 1978, designating the reach between Gavins Point Dam and Ponca State Park as a national recreational river. As part of that process, an "Umbrella Report" prepared by the United States Army Corps of Engineers and the Bureau of Outdoor Recreation in 1977 indicated that such structures "must be removed upon termination of useful life."

The arrival of National Park Service operations staff in the early 1990s led to conversations about the pier's

Since the 1950s, a pier that once helped support a gas pipeline stood in a reach of the Missouri River designated in 1978 as a wild and scenic river (inset). Dismantled in early 2007 when river volume was very low, the pier (above) was about 25 feet (8 m) high with 12-foot-diameter (4 m) pillars beneath a concrete block 20 feet (6 m) high, 45 feet wide (14 m), and 3 feet (1 m) thick, and supported a steel superstructure and two 132-foot-tall (40 m) towers. Its partner—on the Nebraska side of the river a quarter mile away—remains standing.

Early in 2007 an unusual landmark disappeared from the middle of the Missouri River between Ponca, Nebraska, and Elk Point, South Dakota.

The Missouri River as it appears today—without the pier.

removal. In summer 2002, national park staff organized a meeting with Northern Natural Gas, the United States Coast Guard, the U.S. Army Corps of Engineers, and the Nebraska Game and Parks Commission to discuss the pier, its ownership, and the legality of its location in the river. The parties soon established that Northern Natural Gas owned the pier and that the Coast Guard had never issued an original permit authorizing its presence in the river. It then followed that the pier had to be removed or permitted. The only way to permit the pier was to show intended beneficial use, but its beneficial use ended in 1950. The only option left was removal.

Under the park's steady prodding, the removal effort gained momentum but permit issues slowed actual progress. By 2006 the necessary formalities for removal had been observed, but receding waters revealed a substantial channel between a prospective staging area on the South Dakota bank and the pier itself, complicating access. The right conditions finally materialized in late 2006 to allow demolition and removal of the concrete pier. Removal began on 8 January 2007 and ended several weeks later. Throughout the course of this outstanding public-private partnership, Northern Natural Gas proved to be an exemplary corporate citizen and cooperated wholeheartedly. In the end the project concluded another step in the national campaign to enhance the natural and recreational values of the Missouri National Recreational River. ■

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5 For the Enjoyment of Future Generations

Employees of the National Park Service are well aware of the key management-related provision of the Organic Act of 1916, which concludes, "for the enjoyment of future generations." The meaning of "enjoyment" may be as nebulous as the future. Nevertheless, what is certain is that the act provides for the enjoyment of all U.S. citizens: those who already visit national parks, those who appreciate them from afar, and those who might visit if invited and made to feel welcome. As a result the National Park Service strives to reach underserved segments of the population so they may venture outside the developed urban areas in which they live and experience national parks. Enjoyment includes derived benefits such as scientific knowledge and inspiration. Thus the National Park Service and its partners are dedicated to implementing programs that will engage the public and increase the relevance of national parks in people's lives. A 20th-century Congress recognized that ensuring the enjoyment of future generations could only be achieved if the quality of park resources and values is left unimpaired. Today park managers encourage neighbors and citizen scientists to transform their feelings of "caring about" into action of "caring for" parks by participating in volunteer and youth programs and internships. The articles and profiles that comprise this chapter highlight parks as training grounds for tomorrow's resource managers; public engagement and citizen concern in protecting natural resources; and the virtues held in common by staff and collaborators to monitor, conserve, and improve park values for the future.

"Only with … improved understanding of ecosystem structure and functioning can park stewards hope to restore the integrity and resilience of impaired parks, to protect nature unimpaired in parks, to mitigate internal and transboundary threats, or to connect people to their heritage with sufficient impact to engender the public commitment needed to preserve parks unimpaired for the enjoyment of future generations."

—Gary E. Davis, David M. Graber, and Steven A. Acker

Managing natural resources that include humans

A profile of Superintendent Woody Smeck

SANTA MONICA MOUNTAINS NATIONAL RECREATION Area in California encompasses 153,000 acres (61,943 ha), only 15% of which is owned by the National Park Service (NPS). Fifty percent of the acreage is privately owned and includes 300,000 people who live inside park boundaries. The rest is state and local parks. The landscape in which the park is situated is the coastal sliver of Mediterranean-type ecosystem found in just four other places on the globe. It contains unusually diverse flora and fauna, of which many species are threatened or endangered. In this context, carrying out the National Park Service mission of conserving resources for future generations and providing visitors with an enjoyable experience is a challenge. Woody Smeck received the Director's Superintendent of the Year Award for Natural Resource Stewardship in 2005 for his achievements in this setting. The award was presented in 2006.

Fire management is one important concern that requires collaboration with the several municipalities, landowners, and agencies that are stakeholders in the park. In the hot, dry summer, major fires have occurred as frequently as every 12 years because of human activities. Mediterranean vegetation requires fire; intervals of 85 years are optimal to regenerate the flora. The fire management plan recently devised for Santa Monica Mountains had to address the need to both reestablish a natural fire cycle and protect life and private property from catastrophic fire events. The park, under Woody's leadership, and local fire agencies took the opportunity to bring all the parties together. What emerged was a plan that everyone could accept. At the urban edges within the park, the plan ensures that vegetation will be kept thin, preventing fire from crossing park boundaries. The plan also includes educating the public to adopt fire-safe housing materials and landscaping. However, in the park's core wild areas, a natural fire cycle will be encouraged.

Outreach is important in protecting this special environment, which supports a large and growing human population. Woody was instrumental in the initiation of the California Mediterranean Research Learning Center and is on its board of directors. Current understanding of the science of Mediterranean-type ecology has some gaps. Through the Research Learning Center, scientists are brought together to collaborate and conduct research to fill these gaps. Then the center disseminates the findings to urban audiences. Unlike the other NPS Research Learning Centers, this one's focus is outreach. The center's staff goes to schools and other meeting places, presents formal lectures and informal talks, and produces and distributes brochures and audiovisual materials. As Woody says, "If we can get people to care about the environment, they will care for it."

Superintendent Woody Smeck.

Woody feels that the biggest challenge to the park is habitat fragmentation due to urban sprawl. Urban development sends fingers out into the wildland and disconnects areas of habitat. This can result in local extinctions of animals like bobcats and mountain lions, and even some plants whose seeds fall far from the parent. Fragmentation increases the presence of urban edge effects that harm life in natural areas. Water is polluted by road runoff, metals, and other toxins. Exotic species are introduced; a quarter of the 1,200 plant species at the park are nonnatives and some are problematic invasives. Feral cats, and even crayfish that are not native, escape into the ecosystem. Poison set out for rats builds up in the food chain and kills coyotes that eat the rats and even the mountain lions that eat the coyotes.

Mountain lions are indicator species that signal the health of the ecosystem. At Santa Monica Mountains, staff tracks mountain lions, coyotes, and bobcats using Global Positioning System–tagged radio collars to learn how the animals use their habitat and where they travel between areas of habitat broken up by areas of urban development. Parks like this one, where developed lands and nature are interwoven, represent what newly created national parks will look like in the future. The role of the national parks, Woody feels, is to inspire a stewardship ethic. In the Santa Monica Mountains, that begins with creating a shared responsibility for protecting natural systems so that species like mountain lions can coexist with people. ■

—Betsie Blumberg, Associate Editor, *Natural Resource Year in Review*

From the urban wilds to the wilderness of national parks: SAMO Youth program transforms lives and launches careers

By Antonio Solorio and John Tiszler

HABITAT REHABILITATION, NATIVE PLANT NURSERY work, trail construction, horse corral repairs, sign replacement, fence repairs, painting projects: these are all in a day's work for inner-city youths participating in the 2006 SAMO Youth program at Santa Monica Mountains National Recreation Area (California).

SAMO Youth program participants and staff enjoy being together on the last day of the 2006 summer program at Santa Monica Mountains National Recreation Area.

Too many teenagers growing up in the city lack an opportunity to venture outside of the developed urban area in which they live. The chaos and clutter of relentless traffic, sprawling malls, buzzing helicopters, and blaring billboards; the dangers of noxious air pollution and jarring noise pollution; and the stress of too many people and too few trees are all part of their daily urban experience. Even at night, when they head outside to take out the trash or catch a breath of air, light floods the sky to the extent that they can hardly experience enough darkness to look up and enjoy the stars.

The SAMO Youth program is part of an ongoing effort to provide a work experience in an environment different from the familiar sights and sounds of the city—where the asphalt ends and trails begin. Since 2000 the program has been providing summer jobs to college-bound high school students. The program reaches out to youths who are in the process of making career decisions, particularly inner-city students who may not otherwise consider the National Park Service as a career choice.

Each year juniors and seniors from high schools in Los Angeles and Ventura counties are recruited and hired as biological science aides for a six-week hands-on summer job. The group is kept small, with only 10 participants, to ensure a quality experience. These students already have an interest in science and the environment. The program couples their academic preparation with practical experience. The work assignments and projects expose the students to different career fields in a typical park operation. These opportunities are deemed essential in the summer, while the students are still in high school, so that they can ponder their own interests and career possibilities. As the student employees accomplish essential work for the park, they also broaden the relevance of the National Park Service (NPS) through inclusion of greater cultural diversity.

In addition to their resource management and maintenance duties, students are required to provide public interpretation. At the beginning of each summer, the youths receive interpretive training that enables them to give park visitors information relevant to the natural and cultural resources of the area. Three times last summer, the students worked with staff to develop a "hands-on, full of fun, family nature day." These events were advertised to the public as "We Go Eco," whereby participants were led by SAMO Youth on a short discovery hike or taught how to make a nature craft.

Emanuel Lara and Elizabeth Alonso, SAMO Youth student employees at Santa Monica Mountains National Recreation Area, perform native plant nursery work for restoration efforts at the park.

"Before my involvement with SAMO Youth, I never had been to the Santa Monica Mountains, Channel Islands, or Sequoia/Kings Canyon National Park. I don't know if I would have ever experienced a trip to those places if it weren't for SAMO Youth. This experience has changed my life and I would consider working for the National Park Service in the future because I have seen how the Park Service works and I like it."

—Oscar Gonzalez, a student at East Los Angeles College working at Yosemite National park for his third summer

In 2006, SAMO Youth participated in numerous complex maintenance, construction, and repair projects, including the maintenance of an ethnobotanic garden at the Native American Culture Center. In addition they conducted reptile and small mammal surveys and stream surveys. They also developed, implemented, and presented group studies addressing wildlife and plant management questions.

In 2006, students also took a weeklong work trip to nearby Channel Islands National Park, where they performed exotic plant removal and habitat restoration in a remote backcountry island setting. During this adventure they were introduced to camping skills, shared their cooking knowledge, and looked out for each other—for some it was their first or longest period away from home and family. After long, hot, and dry workdays, they cooled off in La Cascada, a spring-fed swimming hole on Santa Cruz Island, or set off on a hike. When it was time to return to base, the students shared a warm crackling campfire and enjoyed the magic of stargazing under a dark night sky.

Over the course of the summer, SAMO Youth program participants experience profound transformations. Their physical and mental strength increases, as does their confidence, as a result of working in the outdoors. The youths receive new and specialized training and have an opportunity to put into practice many skills, including problem solving, peer interaction, enhanced communication, and teamwork. Program leaders find that students who join the program after their junior year in high school often return the following summer with confidence and pride, eagerly accepting leadership roles for the incoming juniors.

As students leave the SAMO Youth program and enroll in college, park staff helps place them at other national parks in seasonal jobs. A number of participants have gone on to choose college majors appropriate to environmental careers, and several have obtained jobs in these fields. One SAMO Youth program participant has already become a permanent NPS employee. All the students who participate in the program, regardless of their final career choice, enter the working world with a greater appreciation of their natural heritage and the role of the National Park Service in its preservation. ■

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Juan Quezada, SAMO Youth program participant, interprets local wildlife for visitors at Santa Monica Mountains National Recreation Area.

Planting the seeds of the future: Engaging youth in invasive species eradication

By Elli Caldwell and Gary King

CARLSBAD CAVERNS, REDWOOD, SHENANDOAH. The heritage of these national parks and of many other iconic landscapes across the country is threatened. The danger is not a headline-generating issue such as climate change, pollution, or drought—at least not directly. The culprit is invasive species: marauding weeds that siphon water supplies, choke off native plants, and upset the balance of ecosystems.

For the past several years teams of volunteers from the Student Conservation Association (SCA) have been inventorying, mapping, pulling, cutting, dousing, and uprooting invasive plants in these and other national parks as well as in national wildlife refuges and forests nationwide. And these efforts are now taking root.

The Student Conservation Association has engaged more than 100 college and graduate students in the Invasive Species Project in 65 national parks since its inception in 2004, including 20 in 2006 alone. The project began as a partnership with the National Park Service's (NPS) Exotic Plant Management Teams, and now also includes the U.S. Fish and Wildlife Service, USDA Forest Service, and Bureau of Land Management. It aims to engage young adults in meaningful service learning opportunities that support resource managers in the restoration of native plant communities. The partnership of SCA and Exotic Plan Management Teams is ongoing, and will continue in 2007.

Linda Drees, NPS Invasive Species Branch chief, says: "The contributions of SCA to our exotic plant management program are invaluable. [SCA volunteers] are a vital component of our strategy, a dependable extension of park resources, and a pleasure to work with."

Department of the Interior Secretary Dirk Kempthorne formally recognized the Invasive Species Project in

Student Conservation Association interns head to work fighting invasive plants at Pictured Rocks National Lakeshore in Michigan.

"[SCA interns] provide excellent service for parks that have limited natural resource staffs."

September 2006 when he presented SCA with a Take Pride in America Award. "Through your stewardship," Kempthorne said, "you are creating a lasting legacy."

To date, SCA volunteers have surveyed more than 26,000 acres (10,520 ha) and treated more than 2,000 acres (800 ha) of infested public land, including 20,000 acres (8,090 ha) surveyed and 1,500 acres (600 ha) treated in the National Park System. Techniques include physical and chemical control involving chain saws, pole saws, brush cutters, loppers, and sprayers. Logging a total of 77,000 service hours, SCA teams have contributed much-needed assistance to public land agencies whose staffs would be unable to complete these projects on their own.

"SCA teams have assisted us over the past two years and have done an outstanding job in removing exotic species," says Stones River National Battlefield Superintendent Gilbert Backlund. "They cleared 17 acres in our park and have helped protect the integrity of the globally rare cedar glade ecosystem. These teams have been a great success from our point of view. They provide excellent service for parks that have limited natural resource staffs."

Tangible accomplishments like those at Stones River in Tennessee are bolstered by the underlying objectives that focus on community outreach, public education, and volunteer enrichment. In addition to rehabilitating the land, each team of interns is charged with educating individuals in surrounding communities about how citizens can contribute to and sustain these efforts. Interns have led field trips for school groups, conducted community events, and hosted volunteer service days. In addition, teams have generated media attention that has raised awareness of invasive species and highlighted the commitment that land management agencies are making to combat this ecological threat.

Over the course of their involvement, SCA volunteers have benefited from the hands-on conservation experience gained by working alongside resource management professionals in the field. Many interns, arriving with undergraduate degrees in biology or ecology, leave with the experience necessary to propel their professional careers. As with many SCA alumni, this year's interns will become land managers of the future. Often the agency supervisors and project managers with whom these volunteers work become invaluable mentors, references, and teachers.

"I now have a better understanding of the connection between local resources and people of all kinds, including politicians, natural resource managers, and members of the surrounding community," says project alumna Faith Sternlieb. "I have been able to apply what I learned as a member of the Invasive Species Project to my education, as well as to my professional endeavors." Faith is working on a master's degree in agriculture with a focus on international natural resource conservation at Colorado State University in Fort Collins, Colorado.

The Student Conservation Association and the Invasive Species Project have led many other young people on similar paths, and if they eventually lead back to their roots at Carlsbad, Redwood, or Shenandoah or to other public lands with urgent conservation needs, we can be sure that these lands will be in good hands. ■

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At Shenandoah National Park in Virginia, SCA volunteers treat invasive plant species using the foliar spray method, a management technique commonly used when mechanical removal is not practical. The foliar spray method involves spraying targeted plants with a low concentration of herbicide.

Citizen concern protects integrity of Hot Springs

By Stephen Rudd

ON 1 MARCH 2006 A LOCAL ARKANSAS RESIDENT made a phone call that would forever change resource management at Hot Springs National Park. This caller reported that his residential well, almost 5.5 miles (9 km) from the park, was now producing water with temperatures as high as 93°F (34°C). Normal groundwater temperatures in the area average 50°F or 60°F (10°C or 16°C) in March, and no geothermal springs had ever been reported outside the park. Two days after the call, investigators from the U.S. Geological Survey confirmed the presence of geothermal water in this residential well.

Prior to this phone call, scientists and resource managers had believed that all the geothermal springs in the park were fed by a single groundwater reservoir that was structurally and stratigraphically constrained within park boundaries. In addition, most of the surficial recharge area was thought to fall within the confines of the park. Under this scenario the risk of contamination from surface sources was low. The recent discovery of geothermal water in a private well outside the park now casts considerable doubt on the simplicity of this model.

Preserving the water resources in Hot Springs National Park requires citizen involvement, multiagency cooperation, and rethinking a long-held scientific model of surficial recharge. The thermal springs feed the recreational and therapeutic baths of Bathhouse Row in the park. Each of these buildings is on the National Register of Historic Places, and all were successful bathhouses for many decades. The Hale Bathhouse (second from the far end) was built in the late 1800s. In its heyday the Fordyce Bathhouse (in the foreground) was very upscale, catering to well-off clientele; it now serves as the park visitor center. Today visitors primarily drink the clean, healthy waters. With the resurgence of spa destinations, however, the National Park Service plans to reopen and lease a number of additional bathhouses along Bathhouse Row.

At the most fundamental level the thermal waters of Hot Springs National Park are valued as a unique and healthy source of drinking water for local and commercial consumption and as a recreational and therapeutic water resource. The park, cultural setting, and local tourism-based economy depend upon these waters. In 1832, 40 years before the establishment of Yellowstone National Park, Congress took action to preserve and protect the springs for the enjoyment of future generations as Hot Springs Reservation, later to become Hot Springs National Park. Originally some 47 individual point sources—part of a remarkably small, oval-shaped belt approximately 1,300 feet (400 m) long and only 300 feet (90 m) wide along the southwestern slope of Hot Springs Mountain—were believed to be the extent of the geothermal springs. Scientists now think that all of the mountains in the park are part of a structurally complex regional arch that hosts the park's geothermal reservoir and extends far beyond the current park boundary to the north and east. The geothermal recharge zone consists of highly deformed and fractured Bigfork chert, Arkansas novaculite, and Hot Springs sandstone, which typify the upland ridges and hilltops.

The new and compelling evidence of the location of the park's recharge zone was the basis for a reevaluation of the potential threat to springs in the park. This new information also casts considerable doubt on the conclusions drawn in an environmental assessment for the construction of a four-lane beltway and its attendant infrastructure, which are poised to traverse the anticlinal complex. Growth in the city of Hot Springs and greater Garland County, which now boasts a population in excess of 95,000, is the impetus for construction. Powerful explosives were used during construction of interchanges of a completed portion of the highway. Though investigators have not yet verified a direct connection with the appearance of thermal water in the residential well, recent highway and interchange construction near the well site provides a high-visibility mark in terms of potential explanation. The proposed footprint for the next phase of construction would employ similar techniques to penetrate the highly resistant novaculite ridges. Explosive charges generate strong shock waves that can seismically

propagate to great depths, creating additional fractures or altering existing ones, and ultimately changing the flow dynamics of the park's geothermal "plumbing system." Also, highway construction and associated development would introduce impervious surfaces; remove soil, regolith, and rock strata; and alter vegetation type and density, thereby causing changes in the characteristics of surface recharge and the quality of water that recharges the system.

The Arkansas Highway and Transportation Department, Federal Highway Administration, U.S. Geological Survey, and National Park Service have now forged a cooperative partnership striving to avoid impairments to the geothermal springs within the park. The two respective highway departments have agreed to temporarily suspend all construction activities and right-of-way purchases and to fund a three-year research effort to better understand the hydrodynamic mechanisms in the area. The U.S. Geological Survey initiated the study at the beginning of fiscal year 2007 with significant NPS input and oversight. The spirit of cooperation among the four agencies has diverted a potentially devastating impact on the primary natural resource of the nation's oldest National Park Service unit. That one fateful call, tendered by a concerned citizen, may well prove to be the key to saving one of America's great treasures. ■

The recent discovery of geothermal water in a private well outside the park now casts considerable doubt on the simplicity of this model.

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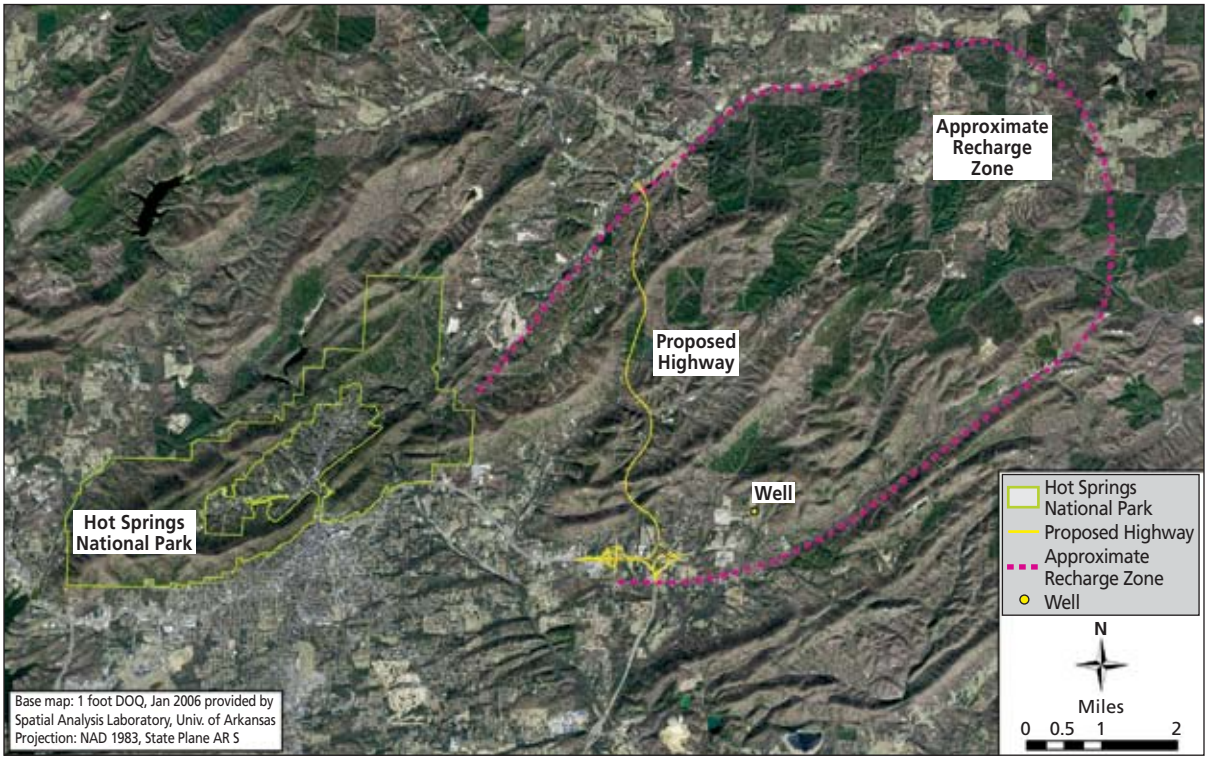

Approximate extent of hydrothermal recharge zone and proposed highway near Hot Springs National Park, Arkansas (February 2007).

Investing in the future with Bandelier birds

By Stephen Fettig

THE FUTURE IS VERY UNCERTAIN: CLIMATE CHANGE and other environmental threats loom as profound challenges for national park preservation. According to Superintendent Darlene Koontz of Bandelier National Monument (New Mexico), cultivating an intellectual and emotional understanding of the value of national parks in our citizenry provides the best hope for addressing an insecure future and for keeping national parks relevant. Hence the Park Flight Migratory Bird Program at Bandelier is making an investment in the future, using close-up experiences with wild birds.

Carina Echave, a homeschooled student visiting Bandelier National Monument, began learning about bird banding as a second grader in 2004. She loves seeing a bird up close and holding it in her hand ("feeling the beat of its tiny heart"). Returning year after year with her family, Carina has become proficient at holding birds and recording technical data.

During songbird banding, visitors of all ages learn about bird/habitat relationships, bird migration, the geography of Central America, and research techniques for answering bird-related questions. In 2006 a total of 344 students, 19 teachers, and 33 other adults participated in the field trips, including traditionally underserved students from local Indian pueblos and Latino communities.

Carina Echave

Since the first year of the project in 2004, René and John Echave have involved their daughter Carina in Bandelier's Park Flight program. Carina is homeschooled, so her parents have the flexibility to address her individual interests. On her first visit to the Bandelier banding station, Carina (second grade at the time) was at the banding table asking questions of Ruby Zambrano, an International Volunteers in Parks participant from Panama. Carina would ask, "What is the weight of the bird?" and "How old is the bird?" She would then record the information in her own notebook with plans to explain the details at the dinner table that evening. In her voice you could hear interest in learning about the birds of Bandelier.

In 2005, Carina returned each week and started learning how to hold and release birds safely. In 2006 she started to systematically record information onto her own data forms to use with other homeschool projects. At the end of the 2006 season, Carina and her family made a special trip to Carlsbad Caverns National Park (New Mexico) to help band cave swallows (*Petrochelidon fulva*). Carina helped carry the cave swallows from the large mist net to the recorders for data processing. She also helped disentangle a few of the birds from the net. Now Carina is at the point of being able to show and explain birds to her younger brother, Giovanni, and to other park visitors. She has already expressed interest in learning more advanced skills at Bandelier, such as measuring wings and tails and determining a bird's age by its color and feather patterns. In slow times at the banding station, Carina and Giovanni create drawings that show a deep emotional connection to birds and the landscape. These spontaneous drawings suggest that the Park Flight experience is making lasting memories for Carina, which may translate into a lifelong commitment to conservation and national parks and even influence her choice of a career.

"Bandelier and its birds will be forever in my heart and mind."

Mary Ristow

The Park Flight Migratory Bird Program relies heavily on the help of local citizens. Mary Ristow, a Volunteers in Parks participant at Bandelier, has been involved in the banding project since the beginning in 2004; she has become a major contributor of volunteer time and a key citizen scientist in the project. The expectation of setting up and taking songbirds out of the capture nets and the anticipation of intellectual challenges, such as determining the age of birds by primary feature growth bars and technical details of molt sequences, keep Mary looking forward to getting up at 4:30 a.m. and making the 75-minute drive to the banding station. Many times, when bad weather prevents park staff from opening the nets, Mary speaks of missing the birds, the park, and "not getting her emotional batteries recharged for the week." For Mary the principal motivation for donating hundreds of hours and thousands of miles on her vehicle is caring for and learning about these birds.

The Park Flight international interns are a close second as a motivating force for Mary. Talking with biologists and educators from Panama, Costa Rica, Honduras, Nicaragua, and Guatemala about how birds connect Bandelier and the National Park System to conservation areas in Latin America has sparked a new international interest: Mary has been studying Spanish in order to better work with Bandelier's international interns. She now talks about traveling to Mexico or Central America, where some of Bandelier's migratory birds spend half the year, to learn about their wintering grounds. On more than one occasion Mary has commented, "It's hard to remember back to when Bandelier wasn't a major part of my life. I would be lost without the birds of Bandelier to fill many of my days each fall. Bandelier and its birds will be forever in my heart and mind." ■

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Wildlife Biologist, Bandelier National Monument, New Mexico

Having banded the first sharp-shinned (*Accipiter striatus*) and Cooper's hawks (*A. cooperii*) of the season made the morning of 8 August 2006 an exciting one for Park Flight volunteers at Bandelier National Monument. Here Mary Ristow, who has been part of the banding crew since 2004, holds a hatch-year Cooper's hawk just before its release. The brown back features with rusty edges help identify it as a hatch-year bird. The relatively large size and the raised hackles on the back of the neck distinguish this bird from a sharp-shinned hawk.

On 1 October 2004, Ruby Zambrano, a Park Flight international intern from Panama, bands a gray-headed junco (*Junco hyemalis caniceps*) while Carina Echave takes notes. Park Flight, which works to protect migratory birds in national parks and protected areas throughout the Western Hemisphere, is a partnership among the National Park Service, the University of Arizona, and the National Park Foundation with the support of American Airlines, a "Proud Partner of America's National Parks."

Monitoring and managing resources in the sea

A profile of Fisheries Biologist Jeff Miller

INVENTORY AND MONITORING NETWORKS OF THE National Park Service are charged with monitoring their parks' resources. For much of the South Florida/Caribbean Network, resource monitoring has to be done under water. "More than half of this planet is under water," says Jeff Miller, "so I have the 'majority' view." Jeff, a fisheries biologist for the network, received the 2006 Director's Award for Professional Excellence in Natural Resources for work performed in 2005 for, among other accomplishments, developing a scientifically rigorous methodology for monitoring coral reefs. He developed the sonar-based random sample selection protocol for establishing long-term coral reef monitoring sites. This protocol was one of only three that satisfied the rigorous sampling criteria of reviewers for the *Journal of Coral Reefs*, who examined 119 such monitoring techniques from around the world.

The value of this permanent monitoring protocol was aptly demonstrated when high water temperatures

NPS Fisheries Biologist Jeff Miller.

The value of this permanent monitoring protocol was aptly demonstrated when high water temperatures initiated a coral bleaching event in 2005 that was thoroughly documented at Buck Island Reef National Monument and Virgin Islands National Park.

initiated a coral bleaching event in 2005 that was thoroughly documented at Buck Island Reef National Monument and Virgin Islands National Park (see article, page 43). This detailed video record of a bleaching event not only is of great interest to scientists but also suggests that there is a way to manage these events. The data revealed that when the corals were stressed by temperature, disease took advantage and was responsible for almost all the death that occurred. Managers of marine parks cannot turn back record warm water temperatures that may be related to global warming, but research may enable them to control the disease that wreaks destruction under excessively warm conditions.

The enabling legislation for Virgin Islands National Park mandates park protection of the coral reefs. In the 2005 event, 51% of the coral was lost from the study site, about 25 acres (10 ha) of what had been some of the most diverse, complex, and coral-rich reefs in the area, growing since about the time that Christopher Columbus was sailing the Caribbean. "We need to raise the alarm that we are rapidly losing this resource," Jeff says, "and we need to focus a whole lot of effort to addressing this situation. There are things that we can do right now to protect the reefs, like control sedimentation, reduce overfishing, eliminate anchor damage, and participate in the public debate. But with bleaching and disease, there is more we need to learn."

Jeff's work is used in marine parks throughout the National Park System. He first saw the need for an inexpensive alternative to the sonar-based protocol while working with monitoring programs in other Caribbean countries, and responded by developing a protocol using handheld Global Positioning System (GPS) units that also produce results that meet scientifically rigorous standards. This system is used in U.S. national parks wherever the sonar-based technology is infeasible. His training sessions in dive physics, physiology, and in-water accident response have been filmed and are used throughout the National Park Service.

In addition to tracking the condition of corals, Jeff was involved in developing methodology and surveying large areas of Virgin Islands National Park to map anchorages that are safe for both vessels and resources. To aid local fishers in navigating those waters, he developed a program to teach them the use of GPS so that they can identify park boundaries and no-fishing areas and increase their safety at sea.

Jeff's work contributes to understanding the marine environment in his network, throughout the National Park Service, and internationally. But he is quick to recognize that he is part of an enormous team effort involving the whole network, the U.S. Geological Survey, and the Student Conservation Association. "When we started monitoring the bleaching event, monitoring quadrupled, and keeping up with that schedule took a whole dedicated team to accomplish." ■

—Betsie Blumberg, Associate Editor, *Natural Resource Year in Review*

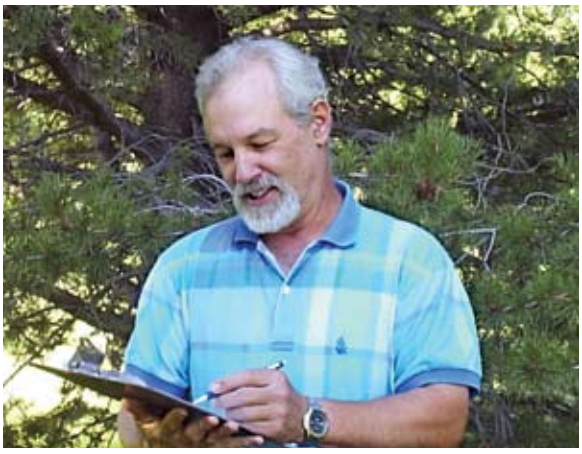
Studying the grizzlies at Yellowstone

A profile of Biologist Charles Schwartz

IN SPRING 2007 THE U.S. FISH AND WILDLIFE SERVICE released the final rule to remove the grizzly bear (*Ursus arctos*) from the endangered species list. The population of grizzlies in and around Yellowstone National Park (Wyoming, Montana, and Idaho) has grown to about 600 from a low of a few hundred in the early 1970s. Recovery reflects the will and efforts of many people; one of them is the leader of the Interagency Grizzly Bear Study Team (IGBST) and recipient of the 2005 Director's Award for Natural Resource Research, Dr. Charles Schwartz of the U.S. Geological Survey. The award was presented in 2006.

The IGBST, established in 1973 and led by Chuck Schwartz since 1998, has been responsible for centralized research and monitoring of the Greater Yellowstone Ecosystem's grizzly bear population. The recovered bear population descends from a small number of bears that survived European settlement of the West and was dependent upon the rich garbage pits of Yellowstone. When the dumps were closed in the 1960s, bears, numbering about 300, became a problem in the park and 229 were killed through management action. A few years later, in 1975, grizzlies were listed as threatened by the U.S. Fish and Wildlife Service. Findings of the IGBST helped establish goals for grizzly bear recovery. A report, "Conservation Strategy for the Grizzly Bear in the Yellowstone Ecosystem," currently guides management of the bears at Yellowstone National Park.

The research involves more than studies of the bears. It includes many plants and animals that share their habitat and whose well-being affects them. Chuck is on the faculty of Montana State University and conducts projects with graduate students. He was aware, for example, that naturally occurring mercury in Yellowstone Lake is taken up by fish, and that when cutthroat trout (*Oncorhynchus clarkii bouvieri*), a key high-protein food for grizzlies, are consumed by bears, mercury is deposited in their fur. Chuck obtained funding to support a student whose research revealed that by analyzing hair for mercury, it was possible to make assessments of how many fish bears ate, and which bears ate them. With these data, investigators can assess the impact of fish loss on grizzly bear demographics. Similarly, he supported a student who discovered a method of quantitatively determining the consumption of whitebark pine (*Pinus albicaulis*) nuts by bears. Such research enables park managers to understand how grizzlies exploit their environment.



Chuck Schwartz of the Interagency Grizzly Bear Study Team.

Of the IGBST Chuck says: "We work for the resource and our job is science. We learn what we can about what's best for the resource, and we are objective. Our data have been used both by the Fish and Wildlife Service to argue for delisting and by environmental groups that oppose it."

The recovery of the grizzly bear at Yellowstone is one of many efforts in understanding large mammals in which Chuck has been a leader. Other parks that have benefited from his expertise in bears and moose are Grand Teton, Glacier, Kenai Fjords, Katmai, Glacier Bay, and Denali national parks, and other units in Alaska and the Rocky Mountains. He has also participated in projects in Canada, Japan, Pakistan, and Russia and produced many publications, which, among others, can be accessed at the IGBST Web site (http://nrmsc.usgs.gov/research/igbst-home.htm). His leadership and innovative approaches are invaluable to managers who need scientific insight into the resources they steward. Chuck is gratified to observe the efforts of the natural resource managers at Yellowstone with whom he has worked for several years. They work hard to keep human food sources away from bears and also to keep people out of bear foraging areas. He says: "This park exemplifies good grizzly management. The staff really does it well." ■

—Betsie Blumberg, Associate Editor, *Natural Resource Year in Review*

Making the most of a small park

A profile of Integrated Resources Program Manager Jason Lott

MANAGERS CAN ACCOMPLISH MUCH MORE BY partnering with agencies that have missions similar to the park's than they can with only the park's resources. This strategy is particularly important at small national parks. Jason Lott is especially gifted at leveraging a park's resources to take advantage of the assets of partners. He exercised this skill as the first Integrated Resources Program manager at Lyndon B. Johnson National Historical Park (Texas), earning the Trish Patterson–Student Conservation Association Award for Natural Resource Management at a Small Park in 2005. He has since become superintendent at an even smaller park, Casa Grande Ruins National Monument in Arizona.

Jason's work with partners at Lyndon B. Johnson has resulted in productive research on control of exotic grasses, a greatly expanded water quality monitoring program, and the park's membership in the Gulf Coast Exotic Plant Management Team.

In pursuit of the park's vision for prairie restoration, Jason contracted with the Lady Bird Johnson Wildflower Center to develop a prairie management development plan. This relationship grew into a cooperative project in which the park hosted plots for research designed by the Wildflower Center to study the effectiveness of various treatments to control King Ranch bluestem, a widespread invasive nonnative grass species. Balcones Canyonlands National Wildlife Refuge assisted the project by conducting the fire treatments. Research results were used for the park's prairie restoration plan and for projects involving fire management.

Jason enhanced the park's water quality monitoring program, working with the Lower Colorado River Authority (LCRA), by doubling the number of monitoring sites to four, encompassing the park's entire surface watershed. To expand the monitoring objectives, he negotiated an agreement with LCRA to host a Hydromet system, equipment that collects data on water flow, depth, temperature, and speed. He also fostered a partnership with the Texas Council on Environmental Quality to place additional equipment at the Hydromet site that monitors pH, conductivity, and dissolved oxygen. He brought in another partner, the Lyndon B. Johnson State Park and Historic Site, to sponsor one of the new sites. Jason personally trained park personnel to operate the monitoring equipment and ensured that they were certified by the LCRA.

Jason Lott at Casa Grande Ruins National Monument, Arizona, where he is now superintendent.

Limited park funds could not support membership in the Gulf Coast Exotic Plant Management Team, but Jason made this possible by arranging housing for three members of the team. Their activities were a great boon to the prairie restoration program. The local presence of the team members also enabled them to work on projects at neighboring San Antonio Missions National Historical Park.

Jason's accomplishments are felt beyond the nearby park. Results of the King Ranch bluestem research are published and will aid prairie management at many National Park System and other federal land management units as well as on private holdings. Jason was instrumental in the inclusion of the Wildflower Center into the Gulf Coast Cooperative Ecosystem Studies Unit. The water quality monitoring program serves as a model for protocols developed by the Southern Plains Inventory and Monitoring Network.

Along with these and other accomplishments in natural resource management at Lyndon B. Johnson, Jason was responsible for managing the park's cultural resources. "My background is in cultural resources and my knowledge about natural resources was limited when I started at this park," he says. "I really enjoyed learning about natural resources, and when you're having fun, you can get a lot done." ■

—Betsie Blumberg, Associate Editor, *Natural Resource Year in Review*

Park maintenance as natural resource management

A profile of Chief of Maintenance Bruce Hancock

IN OCTOBER 2006, WHITMAN MISSION NATIONAL Historic Site in Washington received three certificates of recognition from the regional U.S. Environmental Protection Agency's Champions of Environmental Leadership and Green Government Innovation Recognition Program. This program recognizes federal employees who are "showing leadership by going above and beyond the call of duty in working to improve the environment and protect natural resources." That definition perfectly suits Bruce Hancock, chief of maintenance at the site and recipient of the Director's Award for Excellence in Natural Resource Stewardship through Maintenance. Bruce has been with the National Park Service for 24 years and not only has accepted its mission to protect natural and cultural resources for future generations, but also practices park maintenance as another aspect of resource management.

Bruce Hancock with three sustainable park features: a maintenance vehicle powered by B20 biodiesel, an off-grid solar light, and a park sign made from recycled plastic.

One resource that he conserves is energy. Under Bruce's guidance, Whitman Mission National Historic Site installed a grid-tied photovoltaic power plant on the roof of the park maintenance building. The 60-panel system has the potential to generate 17,975 kilowatt-hours of renewable energy per year. It has reduced the park's electric bill by 30% annually. When this solar system is generating electricity, the excess is fed back into the Pacific Power and Light utility grid, thus reversing the electric meter and offsetting the park's electrical use by that amount.

Another sustainable practice Bruce leads is the park's use of biodiesel. Because the park does not have its own fleet of vehicles, heating oil was the place to start working with renewable fuel. Bruce and his team decided to test a B20 blend, consisting of 20% soybean oil and 80% diesel fuel, to heat the maintenance shop. B20 was not available locally; however, pure B100 soybean oil was available from a supplier 250 miles (403 km) away. The team brought a load of this back to the park and blended their own. It worked so well that they expanded its use to heating the 6,800-square-foot (632 sq m) visitor center and all diesel-powered equipment parkwide. As a result, annual fuel costs have been reduced by 10%, and emissions of carbon dioxide, nitrogen oxide, sulfur dioxide, and particulate matter released into the environment have also been decreased. Ultimately, Bruce encouraged a local fuel supplier to carry biodiesel.

Under Bruce's management, the park's water consumption was reduced by 25% in an area with a limited water supply. When the park residences' heating and cooling system needed replacing, Bruce reviewed many alternatives and settled on a high-efficiency propane system that saved 600,000 gallons (2.3 million liters) of water annually. He also retrofitted park restroom facilities with low-flow and waterless flushing fixtures. Landscaping features native, drought-resistant plants irrigated using timers set to minimize water loss through evaporation.

These are only some examples of the green practices employed at the national historic site. The park has become a showcase for sustainable practices in daily operations. In rural eastern Washington, Bruce frequently had to educate contractors and suppliers about conservation technologies. Seeing these technologies in operation, local contractors, private individuals, and city and county government departments have requested assistance in implementing similar measures.

Bruce is stewarding resources in all of his maintenance operations. His team also often performs natural resource conservation work because the park does not have a natural resource staff. At Whitman Mission National Historic Site maintenance and natural resource management are complementary, which the name of this director's award suggests. "We're all here to protect natural and cultural resources for future generations," he says. "That idea was instilled in me long ago when I first started working for the National Park Service." ■

—Betsie Blumberg, Associate Editor, *Natural Resource Year in Review*

Protecting air, aquatic, and wilderness resources at Mount Rainier

A profile of Natural Resource Manager Barbara Samora

IN 2005 THE DIRECTOR'S AWARD FOR NATURAL Resource Management went to Barbara Samora, who came to Mount Rainier National Park (Washington) in 1988. Barbara manages three programs at the park: the Aquatic Program, the Atmospheric Program, and the Social Science Program. These seemingly disparate areas of expertise grew, in a logical sequence, out of her training with the National Park Service (NPS) and her experience at Mount Rainier.

Barbara participated in the first natural resources training program offered by the National Park Service, from 1982 to 1984. When she came to Mount Rainier from Cape Cod National Seashore, her position was Wilderness and Aquatic Program coordinator. Through her wilderness responsibilities, she encountered issues of visitor experience versus visitor impacts on natural resources. Her aquatic responsibilities led her to focus on one of the threats to the park's lakes: air pollution.

Mount Rainier's lakes are affected by acidic compounds of sulfur and nitrogen from atmospheric sources. These compounds are harmful to aquatic life such as plankton, macroinvertebrates, and amphibians. Many of the lakes have low acid-neutralizing capacity, so their ecosystems are very vulnerable to acid deposition, including compounds that enter the lakes through snowmelt. To better understand the fluctuating levels of these deposits and to relate that information to the condition of the living systems in the water, Barbara develops and oversees several projects that involve compiling data on physical, chemical, and biological variables for park lakes. The condition of the lakes is a "vital sign" of ecological health, so designated by the North Coast and Cascades Inventory and Monitoring Network, which Barbara advises.

Having already concerned herself with air quality as it relates to water quality, Barbara became manager of the park's Atmospheric Program when another staff member retired. An early challenge was to reduce atmospheric sulfur coming from several industrial sources, the major one being a coal-fired power plant in Centralia, Washington. The park worked with staff from the NPS Air Resources Division and the USDA Forest Service, using data collected from the lakes to make the case that air pollution was threatening water quality as well as visibility. In the late 1990s, the power plant reduced its discharge of contaminants by 70%, and this improvement is beginning to be reflected in the air quality monitoring data for the park.

A committed scientist, Barbara understands what information needs to be gathered and designs and supervises multiple projects and personnel. Beyond Mount Rainier, she is an important contributor to such regional programs as the Western Airborne Contaminants Assessment Project and the North Coast and Cascades Inventory and Monitoring Network, and works with the NPS Air Resources and Water Resources Divisions, as well as with many federal, state, and academic partners.

Natural Resource Manager Barbara Samora.

Finally, with her social scientist's hat on, Barbara is currently coordinating the Visitor Experience and Resource Protection (VERP) planning for the park. When she came to Mount Rainier, she was assigned to write the park's first wilderness plan, which included addressing visitor experiences and recreational use effects on natural resources. Barbara is now working with other park staff to update the 1989 plan to incorporate an evaluation of current conditions impacted by recreational use, such as vegetation trampling, soil erosion, wildlife habituation, and water quality. With these impacts identified and standards for the acceptable conditions of the resources defined, the park can better manage recreational use and natural resources. The VERP framework will include all zones of the park. The scope of this project is unique, says Barbara. "It's never been applied on the scale of an entire park." ■

—Betsie Blumberg, Associate Editor, *Natural Resource Year in Review*

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Michael Melford/National Geographic Image Collection (autumn-hued forest with morning fog, Acadia National Park, Maine)

2 Bill Hatcher/National Geographic Image Collection (hiker and Vernal Fall, Yosemite National Park, California)

(epigraph) Udall, S. L. 1995. Foreword to Our National Park System: Caring for America's greatest natural and historical treasures, by D. F. Rettie. University of Illinois Press, Urbana. Page x.

4–7 Photos credited in respective chapter listings below; **9** NPS/Jeff Selleck

Chapter 1—Protecting the Integrity of National Park Resources and Values

10 Don Davis, Pennsylvania State University; Washington State University/Leslie Riley

(epigraph) O'Brien, B. R. 1999. Our national parks and the search for sustainability. University of Texas Press, Austin. Page 63.

11–12 NPS Visitor Services Project (2); **13** NPS/Robert Manning (6); **14** Park Studies Laboratory, University of Vermont; **15** John A. Volpe Center, Department of Transportation; **16** NPS/M. Sarah Creachbaum; **18** USGS, Menlo Park/D. M. Miller; **19** NPS/T. Fisk; **20** USGS, Menlo Park/D. M. Miller; NPS/T. Fisk; **22–23** NPS/C. Schelz (2); **24** Washington State University/Leslie Riley (2); (map) Department of Ecology, Montana State University, and School of Biological Sciences, Washington State University; **25** Washington State University/Leslie Riley; **26** NPS/New River Gorge National River (2); **27** NPS/Shenandoah National Park; **28** Don Davis, Pennsylvania State University; **29** NPS/Air Resources Division; **30** NPS/Jens Hilke; (inset) NPS/Wendy B. Cass; **31** NPS/Steve Bair; **32–33** NPS (2); **34–35** NPS/Stuart West (3)

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36 University of British Columbia Botanical Garden and Centre for Plant Research; Eric D. Fleek, North Carolina Division of Water Quality

(epigraph) Leopold, A. 1949. A Sand County almanac and sketches here and there. American Museum of Natural History special member's edition. Oxford University Press, London. Page 196.

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62 Museum of Comparative Zoology, Harvard University; Alaska Department of Fish and Game/Larry Aumiller

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Chapter 4—Taking Action to Protect and Restore Native Species

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114 NPS/Stephen Fettig; USGS/Caroline Rogers

(epigraph) Davis, G. E., D. M. Graber, and S. A. Acker. 2003. National parks as scientific benchmark standards for the biosphere. Or, how are you going to tell how it used to be, when there's nothing left to see? Page 131 *in* D. Harmon and A. D. Putney, editors. The full value of parks: From economics to the intangible. Rowman and Littlefield, Lanham, Maryland.

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Joel Sartore/National Geographic Image Collection (grizzly bear cubs, Hallo Bay, Katmai National Park, Alaska)

Natural Resource Year in Review is printed on recycled paper.
For a printed copy contact the managing editor by e-mail or write:

Jeff Selleck
National Park Service
NRPC/OEO
P.O. Box 25287
Denver, Colorado 80225-0287

Year in Review is also published online (ISSN 1544-5437) at www.nature.nps.gov/YearInReview.

The National Park Service gratefully acknowledges the National Geographic Society and its Image Collection for their contribution of photography used in this edition. The society is a partner of the National Park Service in support of a variety of programs.

Suggested article citation

Miller, A. E. 2007. Understanding biological diversity of nunataks in southwestern Alaska. Pages 49–51 *in* J. Selleck, editor. Natural Resource Year in Review—2006. Publication D-1859. National Park Service, Denver, Colorado.

Related publications

Readers who find this publication useful may enjoy reviewing *Park Science* (ISSN 0735-9462), a semiannual journal of the National Park Service that links research findings in the natural and social sciences to park natural resource management. *Park Science* is published online (ISSN 1090-9966) at www.nature.nps.gov/ParkScience.

Cultural resource stewardship issues are explored in NPS publications described at www.nps.gov/history/publications.htm. In addition to a variety of reports and specialized publications are the periodicals *Common Ground: Preserving Our Nation's Heritage; CRM: The Journal of Heritage Stewardship*; and *Heritage News*, a monthly e-newsletter.

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
Office of Education and Outreach

P.O. Box 25287
Denver, CO 80225-0287

ISSN 1544-5429
D-1859/December 2007
www.nature.nps.gov/YearInReview

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