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-1755/April 2006

Natural Resource Year in Review–2005

National Park Service / U.S. Department of the Interior

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National Park Service
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Natural Resource Program Center
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# Natural Resource Year in Review–2005

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

*The parks kindle the wish*

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


to discover the world in which we live

*and to sample the world of our forebears*

*and the places and things that bridge the gulf*


of time that separates us from our past. . . .


Our National Parks are places
to be experienced with all one's senses.
—Dwight F. Rettie

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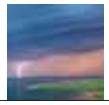
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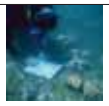
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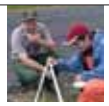


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# The Year 2005 in Review

*By Michael Soukup*

**EACH *YEAR IN REVIEW*** attempts to characterize the year from the perspective of natural resource events in national park units. For 2005 we begin with hurricanes and devote our lead article (see facing page) to summarizing their effects on park natural resources. However, my impression of 2005 was shaped at the World Wilderness Congress in Anchorage in September where the hallways were buzzing with concern over new estimates of polar ice cap melting and its impact on polar regions, indigenous people, national parks, and polar bears—and other issues. Talk of "tipping points" began to show up in the press. I was reminded of what J.R. McNeil wrote in *Something New Under the Sun* (W.W. Norton, 2000): "What Machiavelli said of affairs of state is doubly true of affairs of global ecology and society. It is nearly impossible to see what is happening until it is inconveniently late to do much about it."

*There have been many … surprises and reasons for encouragement about the sustainability of nature and biodiversity.*

Amid the many advances we report for national park resources—the result of hard work by NPS staff, our partners, and volunteers—there was also a sense of urgency in developing our role as educators. Many of us in the National Park Service believe that planet Earth needs an Organic Act like the one that directs society's relationships, activities, and management in national parks: providing for enjoyment but first taking care to "conserve the scenery and the natural and historic objects and the wild life therein." It would seem that those who work at this daily would have lessons to share with park visitors and the public at large about enjoying our natural heritage, sustaining our quality of life, and protecting the future of this nation (and perhaps the planet).

Those lessons are being brought to light in national parks by a combination of focused resource management programs and research. For example, there are many restoration projects that are making our national park resources healthier. Our park inventories and monitoring networks are finding, tracking, and reporting on resources and their condition. The All Taxa Biodiversity Inventory, begun in Great Smoky Mountains National Park with volunteers and private contributions, is spreading to other national and state parks. It is a recent example of responsible environmental leadership emerging from a park that has national implications. Early research on the role of fire in forest dynamics, barrier island dynamics, and monitoring (at Channel Islands National Park) is another example of environmental knowledge needed and provided by the National Park Service that benefited not

only park managers but also the public at large. Along the way, there have been many other surprises and reasons for encouragement about the sustainability of nature and biodiversity. One absolutely spectacular example of the contribution that protected areas make to society occurred this year in a national wildlife refuge: apparent discovery of a small population of the ivory-billed woodpecker! Similarly, the investment in air quality monitoring in the national parks, which began about 20 years ago, is now producing results and helping shape federal and state air quality management programs around the country.

In August I was honored to testify at Senator Akaka's field hearing at Hawai`i Volcanoes National Park on the NPS program for managing invasive nonnative plants. I had an opportunity to listen as state and private groups testified on the key role this park had played in raising awareness and addressing the problems that exotic plants and animals were causing for native Hawaiian fauna and flora. For the first time I fully realized the broad impact parks can have on shaping reasonable approaches to issues that will affect the quality of life in their local communities and regions. Harnessing the potential of national parks for teaching practical stewardship skills and science can provide important benefits to this and future generations. Though such benefits may not be explicit in the Organic Act, they are logical and legitimate outcomes that bode well for the nation's natural heritage and future.

The year closed with intense discussions in political circles, in Congress, and in the press about whether there was a need to change the National Park Service's management policies and perhaps the Organic Act itself. At the same time, discussions started here in Washington about planning the centennial (in 2016) of the Organic Act and the National Park Service. While the anniversary is a decade off, I believe the record, and the American public, will speak for keeping the National Park System on its present track because the Organic Act and the National Park Service are serving well and in ways that could not have been foreseen in 1916.

Mike Soukup

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# Impacts to national parks from 2005 hurricane season coming to light: A preliminary overview

*By Rebecca Beavers and Jeff Selleck**

**TROPICAL STORMS AND HURRICANES** in the Atlantic Ocean were extraordinarily active, destructive, and costly in 2005. A record 27 named storms, which included 15 hurricanes, 7 of them major, killed more than 1,200 people with thousands more displaced or unaccounted for, and caused more than $200 billion in damage in the United States. An unprecedented three hurricanes reached category 5 of the Saffir-Simpson hurricane scale with sustained winds of more than 155 mph (249 km/h). In addition, storm surge from Hurricane Katrina (estimated in the 30- to 35-foot [9.2–10.7 m] range at Waveland, Mississippi, northeast of New Orleans) was the highest ever recorded in the Western Hemisphere and contributed greatly to the damage caused by the massive storm. Among the affected areas are national park units along the Atlantic and Gulf of Mexico coast from North Carolina to Texas. Though no NPS staff were killed, the severe storms had tremendous human costs and catastrophically impacted both natural and cultural park resources and infrastructure, particularly at Cape Lookout (North Carolina), Gulf Islands (Florida and Mississippi), and Canaveral (Florida) National Seashores; Everglades, Dry Tortugas, and Biscayne National Parks and Big Cypress National Preserve (Florida); Jean Lafitte National Historical Park and Preserve and New Orleans Jazz National Historical Park (Louisiana); and Big Thicket National Preserve (Texas).

In August and September, Hurricanes Katrina and Rita made landfall near parks along the coast of the Gulf of Mexico. Preliminary surveys indicate the storms introduced salts to freshwater environments and also toppled native canopy trees. In contrast, Chinese tallow—an exotic tree species—and the nonnative nutria—a rodent—survived. Barataria Preserve in Jean Lafitte National Historical Park and Preserve experienced a pulse of highly saline water following Rita. Salinity stress and long-term damage to the unique freshwater marsh there may follow. Storm surge from Katrina had already "accordioned" the distinctive, thin-mat floating marsh, resulting in lateral compression folds and retreat of the marsh by about 200 feet (61 m) along a 1-mile (1.6 km) stretch of shoreline in one day, or the equivalent of marsh normally lost to erosion in 10 years. Scientists concluded that compression of Louisiana marshes after Hurricane Andrew in 1992 contributed to a shift in species dominance, and a similar impact may result from Katrina. In Texas at Big Thicket National Preserve, forest canopy damage was extensive, and at Padre Island National Seashore tons of hurricane-transported debris drifted ashore, requiring extensive cleanup by the park hazardous materials team.

The Florida unit of Gulf Islands National Seashore was still recovering from Hurricane Ivan (2004) when Hurricanes Cindy, Dennis, Katrina, and Rita plus Tropical Storm Arlene affected the park. Major portions of the 15 miles (24 km) of park roads on Santa Rosa Island that Ivan had washed out were under repair in 2005 when a series of storms destroyed the roads again. These roads were the primary means of public access to the popular park beaches and historic Fort Pickens near Pensacola, and whether to rebuild them—given the degree of natural erosion on the barrier island and unpredictable encroachment—has become the subject of controversy and public debate. At the request of the NPS Development Advisory Board, Gulf Islands managers will evaluate the feasibility of interim measures for visitor access that are compatible with natural barrier island

Natural Resource Management Specialist Riley Hoggard of Gulf Islands National Seashore surveys Santa Rosa Island road, claimed by the Gulf of Mexico in a series of brutal hurricanes and tropical storms in 2005. The asphalt route had provided the only automobile access to the popular park beaches and historic Fort Pickens, located near Pensacola Beach, Florida (seen in background). Managers now face the difficulty of reestablishing park access in a way that accommodates ongoing natural processes of barrier island erosion and accretion.

SEVERE STORMS AFFECTING COASTAL UNITS OF THE NATIONAL PARK SYSTEM IN 2005

| Storm | Date and Place of Landfall | Wind Speed and Classification at Time of Landfall | Primarily Affected Park(s) | Primary Resource Damage/Change(s) |
|---|---|---|---|---|
| *Atlantic Ocean* | | | | |
| Cindy | 6 July; Grand Isle, LA, and near Ansley, MS | 75 mph; category 1 hurricane | Gulf Islands (FL) | Access road damaged |
| Dennis | 10 July; Santa Rosa Island, FL | 121 mph; category 3 hurricane | Gulf Islands (FL) | Access road destroyed |
| | | | Dry Tortugas | Key breached, channel deepened |
| Katrina | 29 August; Buras, LA | 127 mph; category 3 hurricane | Everglades (25 August) | Trees defoliated and blown over; significant sediment deposition and major erosion; concessions facilities and housing damaged; vehicles destroyed; campground closed |
| | | | Gulf Islands (MS) | Barrier islands breached and truncated; extensive erosion and vegetation damage, including trees; wildlife likely impacted; Fort Massachusetts damaged; visitor center heavily damaged; voluminous debris accumulation |
| | | | Jean Lafitte | Floating marsh torn and compressed; trees damaged; Chinese tallow invasion expected; massive shoreline erosion; visitor center damaged; employees displaced |
| Ophelia | 15 September; offshore of Cape Lookout, NC | 86 mph; category 1 hurricane | Cape Lookout | Barrier island breached, creating inlet |
| Rita | 24 September; Texas-Louisiana border | 121 mph; category 3 hurricane | Big Thicket | Enormous amount of tree loss blocking trails and roads; high fuel load anticipated for 2006 fire season; headquarters damaged |
| | | | Jean Lafitte | Saltwater intrusion of marsh, swamp, and forest; trees damaged and lost; changes in vegetation expected |
| | | | Padre Island | Gulf debris washed ashore |
| Wilma | 24 October; Cape Romano, FL | 121 mph; category 3 hurricane | Big Cypress | Road and culverts damaged; nonnative plant invasions expected; roosting trees for endangered woodpecker damaged |
| | | | Biscayne | Bay partially emptied; corals damaged |
| | | | Canaveral | Beach erosion; around 1,000 (of 3,600) sea turtle nests lost |
| | | | Everglades | Mangrove defoliation |
| *Pacific Ocean* | | | | |
| Olaf | 16 February; Samoan archipelago | Category 5 cyclone | National Park of American Samoa | Trees broken and blown down; birds, fruit bats, and coral reefs likely impacted |

processes. At the Mississippi unit of Gulf Islands, Katrina's 17- to 35-foot (5.2–10.7 m) storm surge and 130 mph (209 km/h) winds flowed over the park, redistributing barrier island sands, removing much of the park unit's vegetation, denuding trees, submerging part of East Ship Island, and truncating Horn Island. Despite these storm impacts, the abundance of nutria tracks observed after the hurricane suggests that active management of this nonnative species will be required to allow native vegetation to recover.

Farther south in Florida in late October, Hurricane Wilma unleashed its storm surge in excess of 13 feet (4 m), damaging a more extensive area of coastal mangroves in Everglades National Park than had been harmed by Hurricane Andrew 13 years earlier and Katrina this year. The defoliation was so severe that researcher Thomas J. Smith (USGS Florida Integrated Science Center, St. Petersburg) expects that the mangroves will continue to die for months to come after the storm. Also hit was Big Cypress National Preserve, which sustained widespread, though not severe, damage to infrastructure and natural and cultural resources. In particular, Loop Road was devastated and culverts that aid freshwater sheet flow throughout the watershed need repair.

After striking these parks, Wilma moved east across southern Florida to Biscayne National Park and Canaveral National Seashore. Biscayne staff observed that over about a three-hour period, winds nearly emptied shallow Biscayne Bay, which took an estimated 10 hours to fill up following the storm. Farther from shore, branching corals were flattened and boulder corals were displaced; however, whether coral mortality can be attributed to the storm is unclear because corals were suffering from widespread bleaching, a sign of stress, before any of the 2005 storms hit. Regarding cultural resources, post-storm reconnaissance by Dr. David Conlin of the NPS Submerged Resources Center indicates that known shipwrecks at Biscayne were minimally impacted and that a covering of fine sediment observed on one shipwreck can even help protect these submerged cultural resources. At Canaveral National Seashore approximately 1,000 of 3,600 sea turtle nests were lost to erosion, and several sections of the coast were washed over or experienced 3–5 feet (1–1.5 m) of dune erosion.

Many of the major storms in 2005 passed over or near Dry Tortugas National Park, southwest of the Everglades. Impacts to coral reef resources, though not documented, are sure to have occurred, as notable changes to park geography have been observed. In particular, some keys or islands gained elevation as a result of the storms while others eroded. For example, East Key was breached briefly, and in July, Hurricane Dennis reopened a channel between Bush and Garden Keys, which was later made deeper by Katrina, Rita, and Wilma. The ramifications of storm surge and saltwater inundation of the mangroves and other vegetation on the Keys will not be known until nesting colonies of birds return in 2006. The frigate bird colony on the south end of Long Key had only 25 nests in 2005, a reduction from previous seasons of 130 nests. Sooty and Noddy terns that nest on Bush Key also experienced lower numbers of nesters in 2005.

Though Hurricane Ophelia never made landfall in North Carolina, the mid-September storm dumped 10 inches of rainfall driven by 90 mph (145 km/h) winds, opening a new inlet three-fourths of a mile (2.4 km) south of New Drum Inlet at Cape Lookout National Seashore. The hurricane also significantly widened Old Drum Inlet, which had been almost closed, and storm surge washed over the national seashore. Though dramatic, these changes do not pose a management issue related to park access. Unlike Gulf Islands National Seashore, Cape Lookout does not maintain a paved access road on the barrier island. Thus natural processes of erosion and accretion associated with severe storms cause only minor changes in visitor access.

A primary impact of the 2005 hurricane season was the number and severity of storms, causing catastrophic loss of life and property and associated human suffering. In response the National Park Service deployed emergency management teams to coordinate shelter and other emergency services in support of dislocated park staffs and area residents in the hurricane-affected areas, and to assess damage to infrastructure and park resources. The NPS incident management teams gave tirelessly of their time to locate employees, establish alternative housing and office space for park employees, and reestablish park operations.

Assessment of resource impacts, both natural and cultural, varied in approach and priority. Tasked with emergency support of parks, the national incident management team hired contractors to assist the Katrina-affected park units with initial resource assessments and emergency stabilization, and resource advisors were requested by parks to guide these efforts. Natural resource issues may not have had a high priority at primarily historical or other parks depending on the need for employee assistance, facility damage, or other circumstances. Longer-term assistance at the most heavily impacted parks emerged as the National Park Service collaborated with the US Geological Survey, NASA, and other agencies and partners, particularly through the cooperative ecosystem studies unit network, to develop strategies for assessing damage to park natural resources. These methods will help improve coordination in compiling scientific information following severe storms in the future. As a result of the collaboration, the National Park Service and its partners have begun to discern the most obvious resource impacts and compile a basic overview of the effects of the 2005 storm season.

Nonetheless, the next hurricane season is approaching and the National Park Service must plan for the assessment and protection of natural resources through monitoring and immediate post-event data collection. These activities need to become a natural part of the incident management structure in response to severe storms. Models for this are the cultural resource disaster team, established following Hurricane Isabel in 2003, and the Burned Area Emergency Rehabilitation team, which responds primarily to wildfires. Ready to go when a park faces resource damage, these teams work within the incident management structure and are efficient in assisting parks with resource stabilization and recovery. Another need is improved interagency coordination for information sharing, including identifying which agencies will study particular storm impacts and planning for access to the data. The CESU network is ideally suited to a role in coordinating data collection, analysis, and peer review by expert scientists. These actions will help the National Park Service prepare for large-scale future storms and more effectively employ science in understanding, protecting, and restoring invaluable park resources. ■

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# Year at a Glance—2005

## january

The state engineer acknowledges that pumping in four basins northwest of Las Vegas, Nevada, may ultimately result in lowered water levels and decreased spring discharge in Devils Hole at Death Valley National Park (California and Nevada) and Ash Meadows National Wildlife Refuge, which preserve the endangered Devils Hole pupfish (*Cyprinodon diabolis*). The state engineer reduces the Southern Nevada Water Authority's request by half and requires the water authority to monitor its pumping and mitigate impacts.

The Natural Resource Program Center assembles its first "coastal team" of natural resource specialists to focus on projects and technical assistance needs at national lakeshores and seashores. The team approach improves collaboration among the Biological Resource Management, Environmental Quality, Geologic Resources, and Water Resources Divisions.

In conjunction with the Air Resources Division, Dr. Robert Kohut of Boyce Thompson Institute completes ozone risk assessments for 32 vital signs networks and the Appalachian and Natchez Trace National Scenic Trails. Based on ozone exposures and environmental conditions, the assessments evaluate a park's risk of ozone injury to sensitive plant species and enable resource managers to make informed decisions regarding the need to monitor the impacts of ozone on plants.

The NPS Environmental Response, Damage Assessment, and Restoration Program publishes the *Damage Assessment and Restoration Handbook*, which provides guidance to park managers on the process of assessing and restoring resources injured by pollution, vessel groundings, and other means. The handbook focuses on the Park System Resource Protection Act (16 USC 19jj), which authorizes the National Park Service to seek civil damages from responsible parties, including the costs of response, assessments, and restoration, and to retain recovered costs for use by affected parks and program offices.

## february

Abigail Miller, deputy associate director of Natural Resource Stewardship and Science, retires after nearly 33 years of federal service. Since 1995, Miller has worked on behalf of the programs and people that support the NPS natural resource stewardship mission. Her achievements are highlighted by the successful implementation of the Natural Resource Challenge, including the Inventory and Monitoring Program, and shepherding natural resources accountability and performance management.

The Secretary of the Interior honors the Park Flight Migratory Bird Program with the "2004 Secretary's Four C's Award" for communication, consultation, and cooperation in the service of conservation. The award recognizes the program's exceptional contribution to collaborative, place-based community and citizen stewardship.

Restructuring of the Natural Resource Program Center is completed. A center director now manages five divisions and three offices: Air Resources, Biological Resource Management, Environmental Quality, Geologic Resources, and Water Resources Divisions; and the Offices of Inventory, Monitoring, and Evaluation; Natural Resource Information Systems; and Education and Outreach.

## march

Mike Soukup, associate director of Natural Resource Stewardship and Science, presents the 2004 Director's Awards for Natural Resources at the George Wright Society conference in Philadelphia. The winners are two park superintendents, two natural resource managers, a researcher, a facility manager, and the recently retired deputy associate director of Natural Resource Stewardship and Science (see profiles starting on page 119).

After a year of testing by staffs at 28 pilot parks, the Environmental Quality Division launches the Service-wide Planning, Environment, and Public Comment (PEPC) system. This online collaborative tool (at http://parkplanning.nps.gov/publicHome.cfm) tracks NPS management projects and compliance with laws to protect resources and supports public communication efforts through comment analysis and response.

The Inventory and Monitoring Program cosponsors an international meeting about using remotely sensed imagery for monitoring national parks. Other meeting cosponsors are Parks Canada, NASA, the Canadian Center for Remote Sensing, and the Canadian Space Agency. This meeting formally commences collaboration on this issue between Parks Canada and the National Park Service and results in a series of short summary papers on key topics.

The strategic planning review meeting of the Air Tour Management Plan (ATMP) results in positive outcomes for the National Park Service, including agreements with the Federal Aviation Administration (FAA) about how sound will be monitored in parks, what constitutes an acceptable decibel level of variance or margin of error in monitoring, the process for NPS input on upcoming ATMP schedules, FAA use of the "precautionary principle" for determinations when the amount of data necessary is not available, and FY 2005–2007 goals for the ATMP program.

With the assistance of the Natural Sound Program, staff at Grand Canyon National Park deploys two acoustic monitoring systems and will set up three additional systems to help expedite the collection of ambient sound data for use in the dispute resolution process concerning overflights at Grand Canyon.

Investigators complete an emissions study of snowmobiles and snow coaches in Yellowstone National Park (Montana and Wyoming). The four-stroke snowmobile engines are cleaner for carbon monoxide and smoke than the two-stroke engines. The snow coaches have a broader range of emission rates, with the cleanest being the 2001 vehicles. Park staff will use these air quality and emissions data to update the Yellowstone winter-use plan.

## april

The Geographic Information Systems (GIS) Division and the Natural Resource (NR) and GIS Program launch NR and GIS Data Store at http://science.nature.nps.gov/nrdata, an intranet-based data and metadata management system. The more than 20,000 records span a wide range of data types, including natural resources, park boundaries, base, GIS layer standards, and natural resource database table standards. Automated posting of geospatial data from Data Store to the federal Geospatial One-Stop meets the Department of the Interior data distribution mandates and broadens the audience of potential data users.

Negotiations with the final responsible party—American Premier Underwriters Company, representing the Penn Central Corporation—result in a consent decree for $500,000 in natural resource damages for the United States at Valley Forge National Historical Park (Pennsylvania). The settlement history of this case began in 1996 after investigators detected polychlorinated biphenyls in a residential area adjacent to the corporation's Paoli Rail Yards facility; they subsequently detected contamination in the Valley Creek watershed, in both sediments and fish tissue, which prompted a fish consumption advisory.

During the largest floods in several decades at Delaware Water Gap National Recreation Area (Pennsylvania and New Jersey), streamflows cause widespread damage to natural and cultural resources and park infrastructure. Shortly after the flood, a team from the Natural Resource Program Center travels to the park to assist managers in developing an action plan for remediation. Wherever possible the team recommends not interfering with natural fluvial processes, thereby promoting the beneficial effects of flood disturbance for aquatic and riparian habitats.

The Air Resources Division deploys portable ozone monitoring systems at new locations: Assateague and Padre Island National Seashores, Dinosaur National Monument, and units in the Cumberland-Piedmont Network. A total of 12 systems are in park units, with 2 being used for data quality assurance.

The Biological Resource Management Division distributes nearly $430,000 to 10 parks to control forest insects and diseases. These funds are transferred annually from the USDA Forest Service, most of which are allocated to the control of hemlock woolly adelgids (*Adelges tsugae*). In addition, several parks receive funds for treatment of various species of bark beetles.

## may

The Water Resources Division publishes coastal water resources and watershed condition assessments on Cumberland Island (Georgia) and Gulf Islands (Florida and Mississippi) National Seashores. Three more assessments follow in August, on Timucuan Ecological and Historic Preserve (Florida), and in December, on Fort Pulaski National Monument (Georgia), and Kaloko-Honokōhau National Historical Park (Hawaii). The assessments are produced in conjunction with the Universities of Georgia, Florida, and Hawaii and summarize the condition of these parks' coastal resources, including water quality, habitat, and invasive species, and also give an overview of resource stressors.

The National Park Service teams up with the US Environmental Protection Agency (EPA) to characterize the extent of contamination from abandoned uranium mines in the Canyonlands area of Utah. The cooperative study between the Geologic Resources Division and the EPA determines the extent and environmental implications of migration of radionuclides and metals from 79 abandoned mine sites in National Park System units in the state.

During two days of fieldwork at Colorado National Monument, geologic team members, including Geologic Resources Division personnel, collect location data on known high-risk rockfall sites, inspect the monument's campground and 23 miles (37 km) of Rim Rock Drive, check selected drainage culverts for protective grating, and develop an outline for the park geologic hazards management plan. Park leadership is taking a proactive approach to better management of the natural process of erosion, which forms both the monument's beautiful vistas and its hazardous landslides and rockfalls.

Seven NPS staff members representing parks, the Washington Office, and cooperative ecosystem studies units participate in the World Conservation Union (IUCN) bison species survival commission meeting. The National Park Service manages most of the identified genetically pure plains bison herds in North America. During the meeting, participants, including representatives from Native American tribes and the Canadian, Mexican, and US governments, draft a conservation action plan for North American bison.

## june

The Natural Resource and Geographic Information Systems (GIS) Program releases the NPS Metadata Tools & Editor v1.0, a Web-based intranet application for editing metadata related to national parks. The application is the recommended authoring tool for metadata that will be published on the Natural Resource and GIS Data Store system.

## july

The Natural Sounds Program enters into a cooperative agreement with the Department of Natural Resource Recreation and Tourism at Colorado State University to collaborate on acoustic issues and visitor experience resource protection (VERP) planning. The partnership will facilitate the creation of an instrument prototype, data collection, and preparation of findings that contribute to the understanding of visitor-experience standards for natural sound conditions in national park settings.

In order to better respond to the introduction and establishment of harmful nonnative snakes and other reptiles in southern Florida, the National Park Service, in cooperation with the US Fish and Wildlife Service and the South Florida Water Management District, conducts a workshop about cooperatively managing these invasive species. A cadre of experts from academia and federal, state, tribal, and nongovernmental agencies participate in this first-time event.

## august

Researchers identify chronic wasting disease in a two-year-old white-tailed buck in Hampshire County, West Virginia—the first known occurrence in this area. The Biological Resource Management Division is working closely with natural resource managers in the Northeast and National Capital Regions to prepare park staffs in these areas to respond to this threat to their deer populations.

During the joint meeting of the western regional and Mississippi River panels on aquatic nuisance species, Water Resources Division staff member John Wullschleger is elected to the executive committee of the western regional panel. This is the first time the National Park Service has been formally represented on this statutorily created panel.

The US Geological Survey, Rocky Mountain National Park, and the Geologic Resources Division (GRD) share the Blue Pencil award given by the National Association of Government Communicators for the book *Roadside Geologic Exploration Around Estes Park, Colorado*. The book presents an illustrated series of self-guided roadside earth science topics in and around the park. It was written by USGS research geologist Jim Cole and published by the Association of Earth Science Editors with GRD funding. The book, sold in park visitor centers, has proven popular.

Four knowledge centers of the Views of the National Parks Web site (http://www2.nature.nps.gov/views/) are selected as online resources for the Digital Library for Earth Systems (DLESE): Cave and Karst, Coastal Geology, Glaciers, and Volcanoes. DLESE is dedicated to the collection, enhancement, and distribution of materials for teaching and learning about Earth systems and serves as the geoscience node in the National Science Digital Library.

Management policies of the National Park Service are being updated. An internal review of the draft results in the October public release of the proposed policy changes.

## september

The Secretary of Energy announces he will approve the final record of decision for remediating uranium mill tailings at Moab, Utah. The decision clears the way for the removal of 11.9 million tons of radioactive tailings, mostly by rail, from the banks of the Colorado River followed by groundwater remediation, benefiting Arches and Canyonlands National Parks and other park units downriver.

In a lawsuit brought by the Sierra Club, a federal district court agrees with the National Park Service that its nonfederal oil and gas regulations are limited in scope and address only activities occurring within park boundaries. Nonetheless the court allows the plaintiff to pursue challenges to the NPS application of the regulations related to directional drilling operations at Big Thicket National Preserve, Texas. The Geologic Resources Division provides support to the Office of the Solicitor and Department of Justice in the litigation.

## october

The Gulf Coast Cooperative Ecosystem Studies Unit (CESU) puts together a disaster team to assess and evaluate resource damage to parks following Hurricanes Katrina and Rita. Working as part of the incident management system, the CESU team gathers post-storm data on inundation of employee residences, contaminants, and resource damage.

Since their inception in 1999, CESUs have managed approximately 3,500 projects valued at more than $100 million, benefiting the National Park System, regional offices, and national programs. Also, the National Park Service has funded research coordinator positions at host universities for 12 of the 17 CESUs.

The National Park Service releases for public comment a proposed update of NPS management policies.

## november

Managers from 11 national parks and their cooperating associations commit matching funds to the Geologic Resources Division for placements of GeoScientists-in-the-Parks (GIP) during FY 2006. This is the highest funding in the 10-year history of the GIP program.

The National Park Service and Federal Aviation Administration (FAA) complete a draft implementation plan for the development of air tour management plans in the National Park System. This plan is the culmination of several years' work.

The National Association for Interpretation (NAI) and the National Park Service sign a formal agreement that paves the way for a comprehensive evaluation of nature centers across the country—including those in national parks—by NPS, NAI, and Colorado State University staffs. The agreement also formalizes the task of developing and presenting natural resources training for NPS resource managers and interpreters using a new NAI facility in Fort Collins, Colorado.

The National Park Service, the US Fish and Wildlife Service, and Southern Nevada Water Authority agree on a plan to monitor the effects of groundwater pumping in basins up-gradient from Devils Hole—a detached unit of Death Valley National Park in Nevada, which is habitat for the endangered pupfish (*Cyprinodon diabolis*)—and Ash Meadows National Wildlife Refuge. Two aspects of this agreement are new to NPS water rights settlements: federal funding from the sale of BLM lands will be used to establish some monitoring sites, and groundwater flow modeling will be used to predict the potential for impacts to Devils Hole's water level, allowing the parties to implement mitigation measures before changes in groundwater flow occur that could affect pupfish.

The National Parks Conservation Association and the National Audubon Society petition the Office of Surface Mining (OSM) to designate a large area adjacent to Big South Fork National River and Recreation Area (Tennessee) as unsuitable for surface coal mining. The petition is based on the need to protect the park watershed, the prevalence of steep slopes and the ineffectiveness of reclamation in such areas, and the presence of endangered species. (In January 2006, OSM, responsible for implementing the Surface Mining Control and Reclamation Act of 1977, finds the petition deficient.)

## december

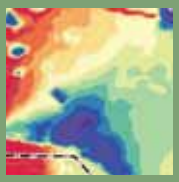
As an outcome of discussions with the National Park Service, the EPA, and environmental groups, Arizona Public Service—operator of the Four Corners power plant, which is a significant contributor to visibility impairment at National Park System units on the Colorado Plateau and the largest source of nitrogen oxides in the country—succeeds in increasing the efficiency of reduction technology for sulfur dioxide ($SO_2$) emissions. The test program results in an 88% total removal rate and a reduction of more than 20,000 tons of $SO_2$ pollution per year.

In response to a provision of the Energy Policy Act of 2005, the Bureau of Land Management (BLM) announces plans to develop a programmatic environmental impact statement to evaluate impacts associated with oil shale and tar sands development in Utah, Colorado, and Wyoming. Given the proximity of these energy resources to multiple units of the National Park System in the West, staff experts at the Natural Resource Program Center begin to identify issues of concern by reviewing the NPS administrative record dating to the early 1980s, when the BLM undertook a similar initiative to lease federal land for such development.

The Geologic Resources Division works closely with the NPS Office of Legislation and the parks to evaluate the implications of proposed amendments to the Mining Law of 1872 contained in the Budget Reconciliation Act of 2005. As proposed, the changes would significantly facilitate the ability of individuals and corporations to obtain ownership of mineral lands, including mining claims in national parks. The controversial mining provisions were dropped from the legislation because of the outcry of a broad array of groups and congressional opposition in both houses of Congress.

# 1 Perspectives on Select Natural Resource Programs

We begin this edition of *Natural Resource Year in Review* with reports from a variety of national programs that focus specialized expertise and resources on



natural resource management of the National Park System. The programs range from those that have been in existence for decades to those that are only a few years old. Many are administered by the Natural Resource Program Center; all are coordinated as part of the Directorate of Natural Resource Stewardship and Science. One of the goals in presenting program reports under this theme is to gain a sense of how the National Park Service is doing with respect to its natural resource conservation responsibilities. The articles that follow provide insights that demonstrate progress on many fronts. For example, after years of monitoring, the Air Resources Division is able to give scientific answers to many questions about air quality in the national parks. Research learning centers are developing into an effective network for advancing national park research. Ocean

> *"We intend to sustain the standard of excellence and personal commitment that the American public has come to expect from the National Park Service. We serve as guardians of vast public treasures, and we plan to pass them along to the next generation in even better condition than we find them today."* — **William Penn Mott, Jr.**

and coastal resources are becoming the focus of intensified and coordinated planning and conservation efforts. Public review of park management and policy proposals is facilitated over the Internet. Partnerships continue to provide significant benefits to the parks. In addition, 12 monitoring networks have begun to monitor park vital signs, a key function for effective park management now and in the future. Not all reports indicate forward movement, but most include encouraging examples of results that come only from focused efforts to improve the understanding, management, and protection of our

national parks.

# Air Quality Program: Information + collaboration = results

*By Christine Shaver*

**THE NPS AIR QUALITY PROGRAM** was created shortly after the Clean Air Act was amended in 1977 to protect clean air, especially in national parks and wilderness areas. Since then, the Air Resources Division, which administers the program, has developed an extensive monitoring network and a wealth of knowledge about the causes and effects of air pollution in parks. Collaborative relationships have been formed with regulatory agencies and stakeholders who have the authority or ability to develop and implement air quality management programs. The National Park Service has been challenged by its lack of control over air pollution that comes largely from outside park boundaries. In addition, as with many natural resource management issues, it usually takes many years to document and disseminate information about resource conditions and trends and to develop and implement solutions. Despite these challenges, the Air Quality Program is an excellent example of how long-term investment in monitoring, research, and relationship-building can promote better protection of park resources.

In 2005, overall air quality was stable or improving in 68% of the parks that have at least six years of on-site data. The most positive trends stem from significant reductions in sulfur dioxide emissions: sulfate concentrations in the air and precipitation (acid rain) have been reduced or stabilized in almost every park, and visibility is stable or improving in all parks. This trend should last because pollution reductions are expected to continue as a result of regulatory or voluntary programs aimed at improving visibility and public health. For example, almost every power plant in the West has installed or has committed to install sulfur dioxide pollution controls. In fact, agreements reached on emission reduction targets and timelines are being not only fulfilled but exceeded. These actions result from more than a decade of collaboration among western states, tribes, federal land managers, and stakeholders.

*The Air Quality Program is an excellent example of how long-term investment in monitoring, research, and relationship-building can promote better protection of park resources.*

Ozone- and nitrogen-related pollution presents more of a challenge. Ozone affects human health and vegetation; nitrogen-related

FY 2005 ANNUAL PERFORMANCE REPORT FOR NPS GPRA AIR QUALITY GOAL Ia3 FOR REPORTING NPS AREAS

The NPS Air Resources Division reported in its FY 2005 performance assessment for GPRA (Government Performance and Results Act) that it exceeded goal Ia3 for air quality in units of the National Park System that report air quality. The goal is for 70% of reporting parks to have demonstrated stable or improving air quality by 30 September 2008. The planned performance target for FY 2005 was 64% of reporting parks meeting this goal, and the actual measure was 68% (34 of 50 reporting parks) that demonstrated improving or stable air quality.

- Park meets Ia3 goal, park air quality stable or improving
- Park does not meet Ia3 goal
- No data / insufficient data

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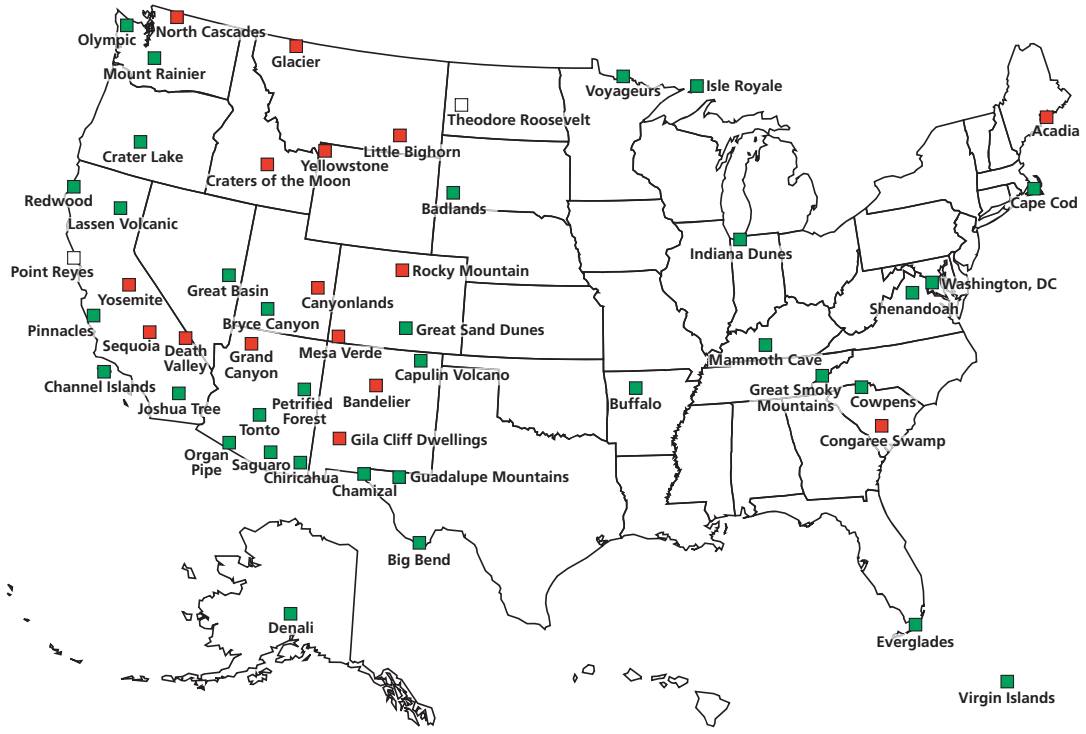
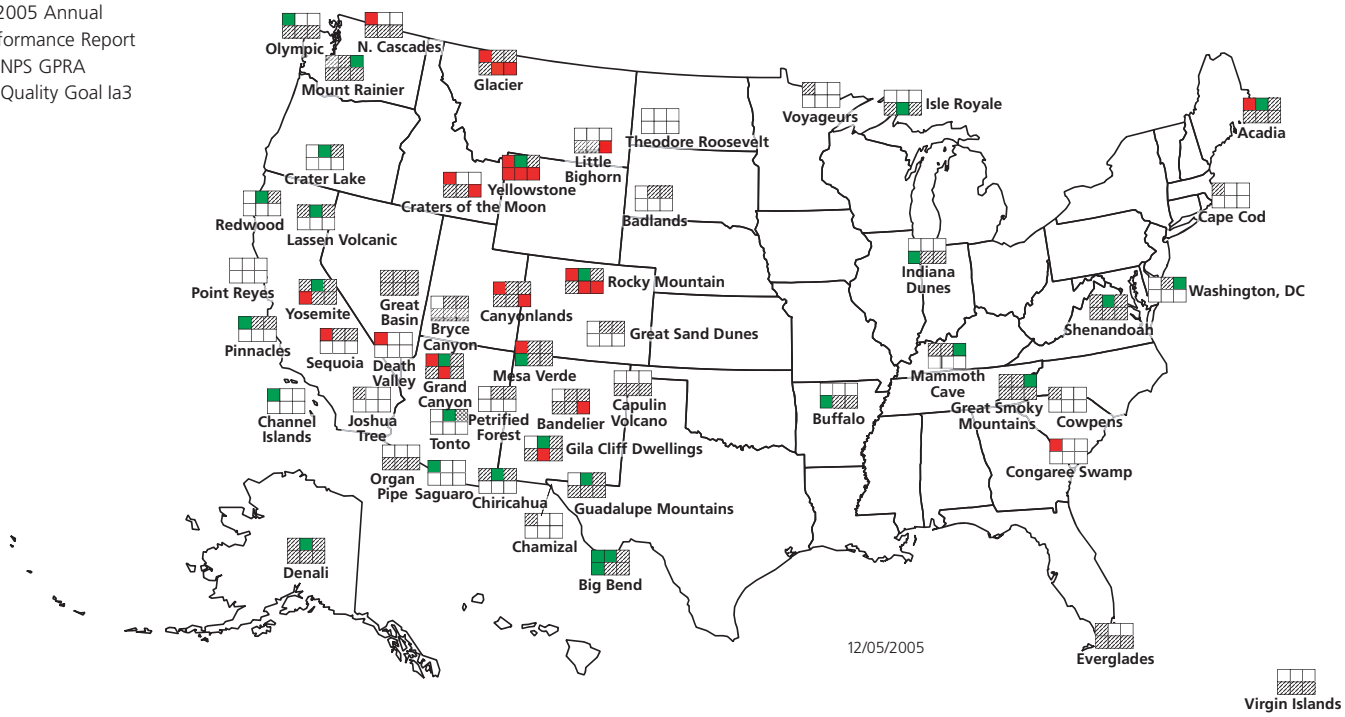


FY 2005 Annual Performance Report for NPS GPRA Air Quality Goal Ia3




*Note*: Statistical significance of p<=0.05 means a 5% or lower probability exists that an identified trend in air quality could be caused by chance.

compounds not only help form ozone but also cause changes in natural systems (e.g., unnatural fertilization, species shifts, nutrient enrichment of water bodies). Pending regulatory programs will reduce ozone pollution in eastern US park units, many of which continue to have unhealthy air but appear to be on the way to recovery. In western parks, however, ozone- and nitrogen-related pollution has been increasing, especially in the Colorado Plateau and Rocky Mountains. Though reductions in emissions from mobile sources are expected owing to federal programs, pollution from other sources—including widespread energy development—could continue to increase.

The trend toward increasing ozone and nitrogen in western parks was detected several years ago through NPS Air Quality Program performance evaluations. Evidence of deteriorating air quality was shared with western state regulatory agencies, and a collaborative effort was initiated to understand why some pollution was increasing and to evaluate the federal program to protect clean air. The National Park Service and western states reached consensus on numerous steps that could be taken to improve effectiveness and accountability. These efforts led to a dialogue about creating a new framework for managing air quality to protect ecosystems.

Growing concerns about nitrogen deposition have helped identify and prioritize new projects involving data synthesis, field studies, and modeling. Existing data at Rocky Mountain National Park were sufficient to convince the State of Colorado that ecological health needs to be protected. A memorandum of understanding signed in 2005 among the National Park Service, the State of Colorado, and the EPA provides the framework to develop strategies to reverse deteriorating trends at the park.

Energy development near national parks—including oil, gas, and coalbed methane and construction of new coal-fired power plants—continues to be a significant challenge facing the NPS Air Quality Program. The National Park Service routinely encourages permitting authorities to require the best pollution controls on new plants and succeeded in lowering the emission limits at five proposed plants in 2005. It also secured commitments from three new power plants to offset their pollution increases with pollution reductions elsewhere in the area. Much of the energy development is not subject to air quality permitting, however, so different strategies are pursued. In 2005 the Park Service helped form the Four Corners Air Quality Task Force (composed of state, federal, and tribal agencies and other stakeholders) to explore technological and adaptive management strategies for

energy development to avoid further air quality degradation. A similar collaborative effort is under way in the Powder River Basin in Wyoming and Montana.

The National Park Service has attracted many partners who share an interest in protecting air quality in national parks. In nurturing these partnerships, quality-assured, long-term data have proven invaluable, as has the Service's increasing ability to model the effects of local and regional pollution increases and reductions. Monitoring technicians, resource managers, and interpreters do an excellent job of ensuring data quality and delivering information to the public. The Air Resources Division has enhanced its ability to perform localized and regional scale modeling and to disseminate information through the Internet (e.g., the Air Resources Information System and Air Atlas make access to data easy, and the air quality Web site receives a million visits per week). Finally, the Park Service has earned a seat at the consensus-building table because of its willingness to engage in constructive dialogue about cost-effective solutions. ■

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## Developing technology and advancing knowledge in soundscape monitoring and protection

*By Frank Turina*

*"Only when one comes to listen, only when one is aware and still, can things be seen and heard. Everyone has a listening-point somewhere. It does not have to be in the north or close to the wilderness, but some place of quiet where the universe can be contemplated with awe."*

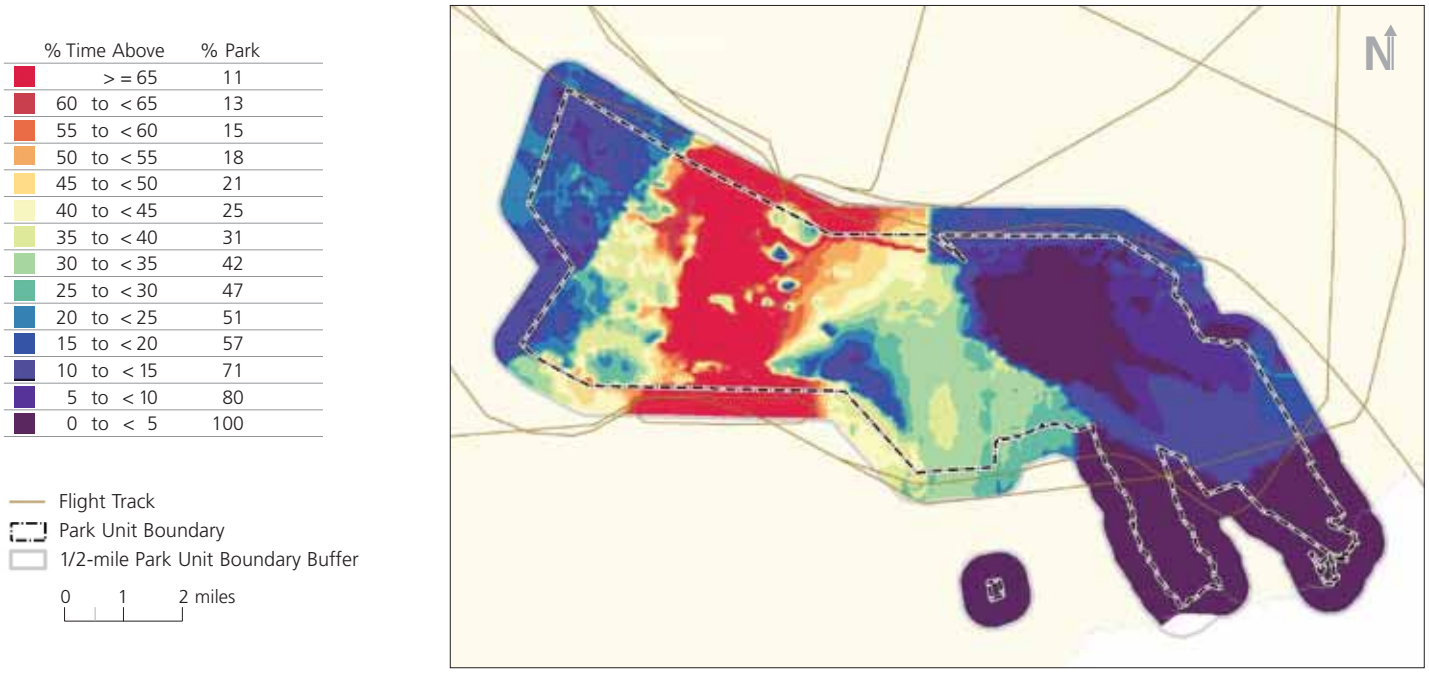
—Sigurd Olson, *Listening Point*

**MANY PEOPLE REPORT THAT** one of their primary reasons for visiting the national parks is to escape the clamor of everyday life and to enjoy the peace, quiet, and solitude that the parks can offer. Noise is a real issue for many Americans. In fact, by 1993 the Environmental Protection Agency estimated that more than 40% of the US population lived in areas where the daily average noise levels exceeded the safe level identified by the agency. Whether park visitors are searching for a lack of noise or for specific sounds, such as an elk bugling in the cool air of a Rocky Mountain autumn, the rancor of bird life in the Everglades, or the thunderous falls in Yosemite Valley, the opportunity to experience an appropriate soundscape can be degraded by unwanted noise from a variety of sources. In 2005 the Natural Sounds Program, part of the Air Resources Division, made great strides in protecting this important aspect of the park experience by developing technical expertise, presenting soundscape management workshops, and advancing scientific investigations in the areas of acoustic monitoring, planning, and protection.

*Whether park visitors are searching for a lack of noise or for specific sounds, … the opportunity to experience an appropriate soundscape can be degraded by unwanted noise from a variety of sources.*

A major emphasis for the Natural Sounds Program in 2005 continued to be implementation of the Air Tour Management Program, a joint effort with the Federal Aviation Administration (FAA) to develop air tour management plans for park units where air tour operators have applied for operating authority. These planning efforts are ongoing at 10 parks in the Midwest, Intermountain, and Pacific West Regions. One of the most significant accomplishments for 2005 was the development of an implementation plan for the Air Tour Management Program. This plan represents an agreement between the FAA and the National Park Service on the procedures and protocols for collecting data, modeling, and describing ambient sound conditions in parks that must develop air tour management plans.

The implementation plan is an important step forward because it addresses program-wide implementation and management issues and describes the process for developing individual air tour management plans, including scoping, alternatives development, and impact analysis. Standards and protocols for measurement techniques, acoustic equipment, and soundscape inventory and monitoring are also presented. Additionally, the acoustics portion of the plan provides an introduction to




The implementation of the Air Tour Management Program, a joint effort with the FAA to develop air tour management plans for more than 100 national park units, continued to be a primary focus for the Natural Sounds Program in 2005. The two agencies reached an agreement on the procedures and protocols for collecting data, modeling, and describing ambient sound conditions in parks that must develop air tour management plans. This map of Haleakala National Park, Hawaii, shows current ambient sound levels, indicating the amount of time that sound levels are greater than natural conditions. This information will serve as a scientific baseline for assessing impacts from current and future activities on the park's acoustic environment.

Acoustic monitoring equipment at Haleakala (left) and Grand Teton National Parks is used to address and monitor natural ambient sound levels for use in park planning.

acoustic principles, terminology, metrics, and measures used to describe and manage soundscapes in national parks. Overall, the implementation plan will assist in maintaining an efficient and effective process for implementing the Air Tour Management Program.

In 2005 the Natural Sounds Program also directly assisted individual parks on a variety of technical issues. For example, to support the development of the air tour management plans, NPS and FAA staffs conducted acoustic monitoring at several national parks, including Yosemite, Acadia, and Great Smoky Mountains. To meet a growing demand from parks for technical assistance, Natural Sounds Program staff presented soundscape management workshops at Mount Rainier and Yosemite National Parks and at several other units in the Northeast Region.

Advancing technology and exploring the effects of various sounds on visitors were also important areas of focus in 2005. Natural Sounds Program staff assisted in the development of a software package for handheld computers that allows staff to easily identify and record specific sounds within a park. The program is also working with Colorado State University (CSU) and others to assess the effects of various sounds on park visitors. For example, in a study at Muir Woods National Monument, California, CSU researchers interviewed 280 people to identify the sounds visitors are hearing at the park and to understand the feelings and thoughts they associate with specific sounds. The findings will be used to inform the development of soundscape indicators and standards at the park. Early in 2006 the Natural Sounds Program will partner with CSU in sponsoring a symposium to discuss research needs and advancements in assessing soundscape preferences in park settings.

The National Park Service is working to address a wide range of challenges affecting not only the natural resources in national parks but also the ability of visitors to enjoy all park resources. In the case of the sounds visitors hear, the Park Service is making tremendous progress in understanding and managing the intrusion of inappropriate sounds through the Natural Sounds Program. ■

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# Office of Inventory, Monitoring, and Evaluation advances mission-critical efforts to document and track park resources

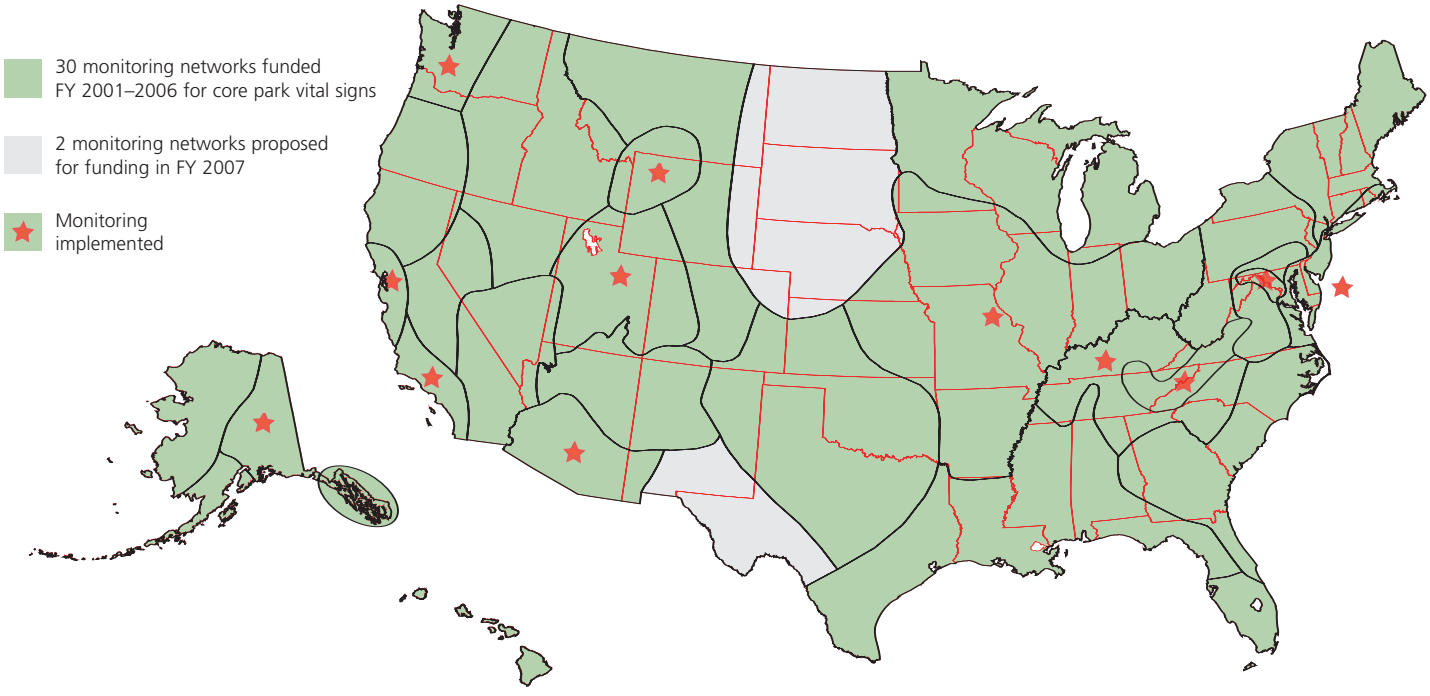
*By Gary Williams*

For the National Park Service the words *inventory* and *monitoring* in recent years have come to mean that it has reached a critical watershed in how it goes about managing the incredibly diverse and widespread natural resources entrusted to its care: with high-quality scientific information. The importance of these functions for realizing the mission of the National Park Service cannot be overstated. Knowing exactly which plants and animals inhabit the parks, where they occur, and in what numbers, as well as the condition of the natural systems they rely on, is the only reasonable starting point for making a broad array of management decisions. The Office of Inventory, Monitoring, and Evaluation (OIME) oversees inventory and monitoring programs throughout the National Park Service, including assisting parks, regions, and other NPS offices with the acquisition of natural resource inventory and monitoring information and its application in management decision making and resource protection. In 2005 the National Park Service advanced monitoring and inventory efforts, assembling 1,750 data sets and completing monitoring plans for more than 100 parks. A comprehensive planning effort to manage NPS information systems was also initiated in 2005.

*In 2005 the National Park Service advanced monitoring and inventory efforts, assembling 1,750 data sets and completing monitoring plans for more than 100 parks.*

The Inventory and Monitoring Program component of the office provides park managers with information about what they manage (through inventories) and the condition of the resources they manage (through monitoring) so that good decisions can be made about actions that affect those natural resources. The program, which began in the early 1990s, has expanded greatly as a result of Natural Resource Challenge funding increases. In FY 2000, the National Park Service organized 270 natural resource parks into a system of 32 networks to provide an efficient means of carrying out expanded inventory and monitoring activities. Park networks will develop and implement programs to monitor the most critical "vital signs," which are measurable indicators of park ecosystem health.

PARK VITAL SIGNS MONITORING NETWORK FUNDING STATUS FY 2006




Six new monitoring networks came online with FY 2006 funding, bringing the total number of funded networks to 30 (green); 2 networks (gray) are proposed for funding in FY 2007 and would complete the planned system of 32 monitoring networks. Altogether, 270 parks have been organized into 32 networks that share staff and other resources for documenting the status and trends of park natural resources in support of management decision making and resource protection. On 30 September 2005, 12 networks (stars) completed their monitoring plans and began to implement vital signs monitoring in their member parks.

**Natural resource inventories**

As of FY 2005, more than 1,750 park data sets (64% of those outstanding) have been developed. This resulted in essentially completing seven inventory data sets for all natural resource parks in addition to making progress on the remaining five inventories. Inventory efforts documented not only species that were commonly found in individual parks, but also threatened and rare species and some that were new to science. For example, the Ozark hellbender (*Cryptobranchus alleganiensis bishopi*), an exclusively aquatic giant salamander that was recently listed as a new federal candidate endangered species, was documented at six new locations within Ozark National Scenic Riverways, Missouri, during recent surveys (see article, page 56). Similarly, biologic inventories at Padre Island National Seashore, Texas, turned up a toad possibly new to science. It appears that the toad population's genetic isolation for several thousand years may have resulted in its distinctive characteristics.

**Vital signs monitoring**

The vital signs monitoring portion of the program began in FY 2001, and by the end of FY 2005, 24 networks encompassing 207 parks had been funded to monitor vital signs. Six additional networks are scheduled to receive funding in FY 2006, with the final two networks to come on line in FY 2007. The 24 networks are involved in a three-phase planning process to develop high-quality monitoring program designs that will provide the best possible information for management use. Each phase is guided by a group representing park managers and undergoes peer review and refinement before being approved for implementation. Overall effectiveness and efficiency are achieved by (1) leveraging costs and expertise through partnerships with more than 150 universities and numerous federal and state agencies, (2) relying on available data and methodologies whenever possible, and (3) organizing and sharing monitoring efforts among parks in the networks.

During FY 2005 the monitoring plans for the first 12 networks, consisting of 101 parks, received final peer review and approval (see article, page 45). As a result, monitoring of key natural resource vital signs will be implemented for these parks beginning in FY 2006. The indicators selected as vital signs vary by park and region. For example, monitoring natural shoreline dynamics and land retreat in the face of rising sea level is basic to understanding the driving forces behind many Northeast Coastal and Barrier Network park ecosystems. The loss of valuable cultural and historical sites and natural resources, such as breeding habitat for the threatened piping plover (*Charadrius molodus*) and endangered roseate tern (*Sterna dougallii dougallii*), is of paramount concern to park managers. Understanding shoreline dynamics will contribute to these management decisions. Other regions may focus monitoring activities on individual species. White spruce (*Picea glauca*) is one species that typifies the boreal forest of the Central Alaska Network. This species constitutes a primary habitat and food source for several bird and small mammal species; therefore, the extent of white spruce across 22 million acres (8.9 million ha) will generally inform the network about boreal forest health.

**PRIDE project**

The Office of Inventory, Monitoring, and Evaluation, in partnership with the Office of Natural Resource Information Systems, recently initiated the PRIDE project in an attempt to plan natural resource information systems with a long-range, comprehensive perspective. This perspective is needed to ensure that managers have accurate information in the format and time frame required. In the past, information systems that provide critical inventory and monitoring data to NPS planners and managers often have not been developed in a coordinated, cohesive manner, resulting in unnecessary redundancies, omissions, and inefficiencies. Just as building a house requires blueprints that show how all components (plumbing, electrical, structural, etc.) relate to each other, so information systems should be developed with the whole picture in mind and with defined relationships between different types of data. This is a relatively new concept for information technology in the government, but one that has proven to be very efficient and cost-effective in the business world.

Over the next 12–14 months, the PRIDE project will focus on five major activities: (1) describing major NPS natural resource management processes, (2) identifying information needed to implement those processes, (3) assessing current information systems, (4) identifying information gaps and redundancies, and (5) developing a modernization blueprint that describes a transition process for going from current to desired conditions. In this manner, PRIDE will undertake a strategic planning effort for natural resource information systems development and deployment from the parks' perspective.

Documenting the plants and animals found in national parks throughout the nation is no small task, involving numerous partners and untold volunteers to get the job done. Similarly, monitoring and data management activities require the prolonged focus of many skilled people. Years of effort have led to a new understanding of the great diversity of life-forms found in the parks and to delivery of information on the conditions of park ecosystems. The ultimate payoff will be the ability of park managers to make better decisions based on science. The programs of the Office of Inventory, Monitoring, and Evaluation are helping to realize this mission-critical goal. ■

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# Scientific discoveries for park managers and the public: Research learning centers make a difference

*By Lynne Murdock*

**INTRODUCED IN 2000 AS PART** of the Natural Resource Challenge, research learning centers advance research in national parks. Fifteen centers now serve more than 100 units in the National Park System. This year the centers and their partners carried out around 660 park research projects valued at more than $8 million. These efforts are increasing the ability of park managers to make resource decisions that are informed by sound science. The centers also hosted more than 240 events this year, including science seminars, teacher workshops, conferences, citizen science projects, and staff trainings, sharing park research results with more than 9 million people in communities near parks and around the world. Another benefit of research learning centers is their capacity to provide low-cost housing and work space for scientists and their students. In 2005, research learning centers provided bunk space, campsites, laboratory and office space, and other amenities that enable researchers to make maximum use of their time and project funds.

*By leveraging facility and staff resources, the centers are reaching outside park boundaries to engage their neighbors and acquire new knowledge for managers.*

Research learning centers facilitated a wide variety of research in 2005, addressing natural, cultural, and historical resources; visitor use and satisfaction; effectiveness in education and community outreach; and park operations and safety. By leveraging facility and staff resources, the centers are reaching outside park boundaries to engage their neighbors and acquire new knowledge for managers. A good example is the public response to loss of marshland in Jamaica Bay, a part of Gateway National Recreation Area, New York. Anecdotal information from local residents and fishers concerned about the shrinking of salt marshes prompted the Jamaica Bay Institute, a research learning center, to facilitate analysis of historical and recent aerial photography. Results showed that 50 acres (20 ha) of wetlands are disappearing annually. If this trend continues, the marsh islands will vanish by 2025. Such credible information prompted many actions within and beyond Gateway's boundaries. A blue-ribbon panel was established to consider the critical loss of wetlands, and funding was obtained for several research projects. A symposium hosted by the institute kept land managers and policy officials up-to-date with the evaluation of salt-marsh loss. The prominence of this issue has guided large-scale restoration of Jamaica Bay, and the mayor of New York City recently decided to develop a Jamaica Bay Watershed Management Plan.

Research learning centers are also proving their usefulness in coordinating research among many parks. A prime example is the ongoing inventory of eumycetozoans, an interesting group of organisms with the common name of slime molds that includes species

Amanda Johnson from Tuscola High School in Waynesboro, North Carolina, looks for brownish purple markings and yellowing on plant leaves in Great Smoky Mountains National Park. Such discoloration can indicate high ozone concentration in the air. Johnson's work is part of a project coordinated by a research learning center, and the school's data contribute to researchers' assessment of air quality in the park.

Acoustic research at Congaree National Park, South Carolina, involves placing autonomous recording units in trees to sample park sounds over several years. In addition to establishing a baseline of the park soundscape, managers are interested in determining the presence or absence of Bachman's warbler and ivory-billed woodpecker, both thought to be extinct, as well as other species of ecological interest: cerulean warbler, northern cricket frog, Fowler's toad, and little grass frog. The Old Growth Bottomland Forest Research and Education Center provided on-site lodging, a work area and computer lab, and access to the old-growth forest. More than 20,000 hours of sound sampled at 10 sites in 2005 is being analyzed.

important in the study of Alzheimer's disease. The project, described on page 68, aims to establish an inventory of the organisms across the National Park System. The work is often carried out by volunteers, who become highly trained citizen scientists who learn culturing techniques and study cell organization, and may also help researchers monitor the health of soil communities. The project is currently being conducted by 11 research learning centers nationwide.

Engaging the public in park science and stewardship issues is a major goal of the centers. For example, at Great Smoky Mountains National Park (Tennessee and North Carolina), high school students are investigating the effects of ground-level ozone using biomonitoring gardens. Managed by the Appalachian Highlands Science Learning Center, the study trains students to measure plant growth of common species such as milkweed and coneflower. They also examine the leaves for evidence of overexposure to ozone, a toxic air pollutant. The project benefits both students and researchers, says Education Specialist Susan Sachs, who coordinates the program. "We have better information to pass on to … researchers, who are often only in the park for a couple of weeks each year, and the students gain an in-depth understanding of air pollution in their community."

Serving national parks in the Pacific Northwest, the North Coast and Cascades Research Learning Network brought together park interpreters and university educators to develop a series of articles for publication in the *Seattle Times* as part of its "Newspapers in Education" program. The idea behind the project was to encourage students to explore science topics using real-world management applications from Pacific Northwest national parks. The related Web site (www.nps.gov/noca/nie) posts articles, accompanying curriculum, and interactive pages for students on a variety of topics relevant to park resources management, such as forest carnivores, forest ecology, volcanology, migratory birds, and glaciology. Students learn about the scientific method and how to apply science methodologies to investigating and understanding the natural world.

Research learning centers are an example of how the National Park Service is actively engaging park neighbors in resource stewardship activities while creatively meeting management needs for quality scientific information. Through methods such as online catalogs that list and describe park-prioritized research needs, enhanced Web sites, resource bulletins, newsletters, roundtable discussions, and science seminars, these centers are making a difference to national park managers, the public, and researchers alike. The future of this vibrant program lies in the centers' collaboration with more than 250 partners, including nonprofits; volunteers; universities; federal, state, and tribal agencies; and a range of internal Park Service programs. Through these partnerships, research learning centers will continue to facilitate research, communicate results, leverage funds, and serve a broad range of park units in 2006 and beyond. ■

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## Park planning streamlined through online review and comment system

*By Julie Fleming, Mohammed Chowdhury, and Shane McGregor*

**PARK PLANNING AND ENVIRONMENTAL IMPACT** assessment began harnessing the power of the Internet to reach broad audiences in March 2005 when the Environmental Quality Division publicly launched the Planning, Environment, and Public Comment system. Known as "PEPC," the online system is a collaborative tool that tracks a wide variety of National Park Service activities relating to conservation planning, environmental impact analysis, and informed decision making in park management. The new system tracks progress with park projects, including the legal compliance process outlined in the National Environmental Policy Act; public comment, analysis, and response by the National Park Service; and implementation of the projects. A significant benefit is the improvement in communication with the public about how parks are being managed. The Internet site, which facilitates public review of project plans, is at http://parkplanning.nps.gov; the internal site at https://pepc.nps.gov allows park staffs to post plans and related documents and review and analyze public comments. The system also improves efficiency of the National Park Service by integrating several key online project and financial planning tools to reduce the number of times data about management projects need to be entered into various systems.

*A significant benefit is the improvement in communication with the public about how parks are being managed.*

In its first year of use, 2005, PEPC is proving popular among NPS employees and the public. Park Service staff and contractors are using it to create and track projects, document site visits and compliance with laws for the protection of cultural and natural resources, and organize and respond to public comments. Washington Office personnel, NPS regional directors, and park superintendents are using PEPC to view detailed and summary reports of planned projects and their funding status, the status of projects with respect to compliance, and trends in public comments. The public, both those with interest in park management and those directly affected by projects, is able to access and comment on notices, updates, related documents, and policies throughout the planning process.

A real time-saver for parks is PEPC's ability to centralize all documents related to a project or activity for internal review; hard copies no longer need to be routed for this purpose. Project milestones, compliance status, images, team member lists, and tasks can all be reviewed quickly and conveniently online. Environmental Quality Division staff, which is developing PEPC, has plans to further reduce the use of paper in park planning by incorporating a mechanism for electronically authenticating signatures in the transaction of park business related to the projects. The staff also plans to develop a system for archiving documents with the NPS Technical Information Center through the use of XML (extensible markup language).

The Planning, Environment, and Public Comment system facilitates online public review of conservation planning, environmental impact analysis, and other planned park management projects. Two recent management activities available for public input are an impact analysis of a trail rehabilitation and access improvement project on Dias Ridge (above) in Golden Gate National Recreation Area (California) and a proposed update to the fire management plan for Wind Cave National Park, South Dakota (below). Nearly 4,000 park planning projects were registered in the PEPC system as of November 2005.

As of 1 November 2005, PEPC was being used to manage nearly 4,000 park planning projects with hundreds of NPS users. The system is also accessible by contractors and other federal partners, such as the Federal Highway Administration. Its success as a public communications system on park planning is exemplified by the nearly 80,000 comments made during the public review period of the "Proposed petroleum exploration well in Glen Canyon National Recreation Area." Another use is the review of proposed updates to NPS management policies, which was open for public comment from 19 October 2005 through 18 February 2006. ■

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# Creativity and dedication to carry National Natural Landmarks Program through budget cut

*By Margi Brooks*

**ESTABLISHED IN 1962, THE NATIONAL NATURAL LANDMARKS** (NNL) Program aims to encourage and support voluntary preservation of nationally significant sites that exemplify the geological and ecological history of the United States. Because the program is voluntary, NNL designation is not a land withdrawal, does not change the ownership of an area, and does not dictate activity. The program involves 587 private, municipal, state, and federal landowners voluntarily preserving sites as national natural landmarks. The regulations that govern the NNL Program were revised in 1999 to better protect the interests of private landowners who participate in it. Publication of these new regulations ended a 10-year moratorium on new NNL designations.

*The NNL Program will continue to support conservation at these nationally important natural areas.*

Though no new national natural landmarks were approved in 2005, progress was still good in many ways. Evaluation of potential landmarks continued, as did projects to interpret and improve conditions at existing national natural landmarks. Similarly, NNL staff visited more than 200 landmarks to document their condition and discuss conservation assistance available from the National Park Service and other partners. The first NNL photo contest was held in 2004, and calendars featuring the award-winning photography at 18 landmarks were distributed worldwide; a second photo contest was held in 2005, with photos depicting 13 landmarks selected as prize winners. The National Park System Advisory Board voiced enthusiastic support for the program at their meeting in September. Additionally, chair of the House Committee on Resources Richard Pombo sent a letter to the Secretary of the Interior supporting the designation of a potential new landmark and the basic tenets of the program.

In spite of a significant budget reduction in FY 2006, creative solutions have been developed to ensure that the program remains effective. For example, regional staff will be reduced from 11 to 6 through retirement incentives, job sharing, and attrition. Remaining program staff members met in late September to hammer out a detailed work plan for 2006 that highlights tactics for addressing the funding cut, including seeking grants, increasing the use of donated services, reducing costs associated with site visits, and increasing promotional and educational opportunities that do not require much travel. In short, despite a significant budget reduction, the NNL Program will continue to support conservation at these nationally important natural areas both within and outside the National Park System. ■

This photograph of a late-summer thunderstorm at Medicine Lake in northeastern Montana won first place in the 2005 NNL photo contest; it was taken by Carter Thurman of Sewanee, Tennessee, and will appear in a 2006 calendar. Managed by the US Fish and Wildlife Service, this national natural landmark highlights a landscape shaped by the processes of continental glaciation.

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# How can the National Park Service improve stewardship of ocean parks?

*By Gary E. Davis*

**A 2001 REPORT BY THE NATIONAL PARK SYSTEM** Advisory Board examining the prospects of the National Park Service (NPS) in the first quarter of the 21st century found that NPS stewardship of ocean resources lagged behind land management. Specifically, it expressed concern that marine environments may be degrading faster than terrestrial areas because of pollution, overfishing, and coastal development. The challenge set by the advisory board was for the National Park Service to be a leader in marine resource protection and restoration and to "think beyond the vision of maintaining sustainable parks to encourage sustainable communities and ecosystems with parks as a part of them."* This challenge prompted creation of a task force of seven ocean park superintendents and seven national program leaders from cultural resources, natural resources, and visitor services directorates, appointed by the NPS deputy director in June 2004. The task force developed a four-point Ocean Park Stewardship Action Plan for 2005–2008, and in 2005 realized several important accomplishments.

*National Park System Advisory Board. 2001. Rethinking the national parks for the 21st century. Report. National Geographic Society.

Addressing the plight of the oceans, the action plan focuses on the cooperative establishment of a coordinated system of ocean parks, sanctuaries, refuges, and reserves. Because the management of ocean resources often varies by agency and oversight responsibility, the National Park Service must work with many partners to develop consistent mechanisms for maintaining and restoring marine resources. The plan also calls for the exploration, mapping, and protection of ocean parks. To ensure success, the Park Service must find more effective ways of engaging visitors in ocean park stewardship as it increases its own technical capacity for ocean exploration and stewardship.

In 2004 the National Park Service worked with the Department of the Interior and the White House to develop the US Ocean Action Plan (December 2004), including provisions for the Park Service to pursue its Ocean Park Stewardship Action Plan goals and increase coordination with other ocean agencies. In August 2005 the National Park Service and the US Fish and Wildlife Service (Wildlife Refuge System) signed an agreement on cooperative law enforcement with the National Oceanic and Atmospheric Administration (NOAA, National Marine Sanctuaries and Fisheries). This agreement will

Marine resources in the National Park System are as varied as they are widespread, occurring in 74 parks from the South Pacific to the Caribbean, and from Alaska to Maine. An action plan to improve their stewardship emphasizes cooperation with other federal and state agencies in developing consistent mechanisms for their maintenance and restoration. Pictured clockwise from upper left are Point Reyes National Seashore (California), Kenai Fjords National Park (Alaska), Virgin Islands National Park (US Virgin Islands), Everglades National Park (Florida), and Assateague Island National Seashore (Maryland).

enhance visitor safety and resource protection in adjacent or overlapping ocean parks, sanctuaries, and refuges. In addition, members of the Ocean Park Task Force met with staffs of the Wildlife Refuge System and NOAA Sanctuaries and Estuarine Research Reserves to develop a broad agreement to expand joint programs for natural and cultural resource monitoring, management, and education and outreach, scheduled for completion in summer 2006.

Recognizing the importance of raising public awareness of ocean park resources and their condition, the National Park Service contributed data that describe 40 ocean parks to a comprehensive inventory of national marine managed areas. The inventory is available to the public at www.mpa.gov. Additionally, the NPS Water Resources Division guided coastal park watershed assessments in 2005 (see article, page 47). Looking to the future, the task force explored ways to improve its effectiveness by coordinating marine habitat mapping and other activities with the NPS Natural Resource Program Center, and by helping to organize an ocean park task force in the Northeast Region.

Overall, 2005 was a year of substantial progress for ocean programs. In 2006 the National Park Service will intensify efforts among the parks, regional offices, and Washington Office programs to realize its vision of preserving unimpaired ocean "wild life," natural processes, wilderness, cultural resources, and recreational opportunities in the National Park System. Activities will focus on increasing the organizational and scientific capacity of the National Park Service for stewardship of ocean natural and cultural heritage, to include developing and nurturing effective partnerships. Achieving these goals will require broad National Park Service involvement and civic engagement. ■

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# Geologic Resources Division unearths solutions for park resource management

*By Dave Shaver*

**GEOLOGY IS A CRITICAL ELEMENT** in prudent resource stewardship in most units of the National Park System. Not only does it serve as the foundation of landscapes and scenery, but it is also an important factor in determining life-forms, water bodies, and microclimates. Identifying and understanding geologic processes in parks, in addition to managing less obvious issues such as the protection of endangered species and emergency response to hurricanes, is a fundamental role for geoscience. Accordingly, the NPS Geologic Resources Division (GRD) works with parks, regions, and monitoring networks to incorporate geoscience information into park decision making. The Geologic Resources Division—part of the Natural Resource Program Center and composed of staff with specialized knowledge in the sciences, policy, and regulatory arena—provides support to park managers and the directorate on a range of geologic resource management issues in and adjacent to parks. Specific program areas include cave and karst systems, coastal and surficial geologic processes, disturbed lands restoration, paleontology, geologic hazards, soil resources management, geologic mapping and issue identification, minerals management, and associated NPS policy and regulatory or legal authorities.

*Geology is a critical element in prudent resource stewardship in most units of the National Park System.*

Highlights of program accomplishments in FY 2005 include restoration of disturbed lands, reaching a milestone in the number of volunteer geoscientists placed in parks, assisting park managers with often contentious minerals management issues, helping to establish the National Cave and Karst Research Institute, initiating a comprehensive monitoring manual, assessing geologic hazards, addressing coastal and marine resource issues, and completing many soil surveys. Specifically, GRD staff assisted managers in more than 30 parks with issues concerning abandoned mines, disturbed lands, geomorphologic resources, and geologic hazards by providing analysis, restoration designs, and project oversight. The division administered NPS funding and managed projects in 12 parks, restoring nearly 300 acres (122 ha) of severely disturbed land. Staff expertise in mining and oil and gas technology, impact mitigation, regulations, and policy helped managers in more than 25 National Park System units protect park resources from the adverse effects of mining and drilling. Using Recreational Fee Demonstration Program funds, the division initiated a comprehensive geologic monitoring manual, which the Geological Society of America will publish in 2006. Specialists assessed geologic hazards such as landslides, rockfalls, snow avalanches, debris flows, floods, and severe erosion at eight parks. Coastal geology staff assisted managers in more than 30 parks with coastal and marine resource issues, in particular helping to evaluate hurricane damage and response. Inventory and mapping staff helped guide the development of new mapping protocols for barrier islands and marine resources, for example at Kaloko-Honokōhau National Historical Park (Hawaii) and Dry Tortugas National Park (Florida).

In FY 2005 the division also helped the National Park Service meet its strategic plan goals for disturbed lands restoration and paleontology, exceeding the targeted estimate for restored acreage and the number of fossil sites held in good condition, respectively. The division contributed to the NPS natural resource inventory goal Ib1 by completing 17 digital geologic maps for parks and 11 soil inventories through the Geologic Resource Evaluation initiative and the Soil Resources Inventory.

Cooperative ventures with professional organizations significantly expanded the division's geologic capabilities in 2005. Partnerships under the Geoscientists-in-the-Parks (GIP) program placed 51 geoscientists in parks and offices across the country to address needs in interpretation, resource management, and research. Since the inception of the GIP program in 1995, these partnerships have placed approximately 500 volunteers (students and experienced professionals) in parks. This contribution is valued at more than $4 million. Partners such as the American Geological Institute, Association for Women Geoscientists, Geological Society of America, US Geological Survey (USGS), and state geologic surveys facilitated research, education, and interpretation and enhanced NPS funds for park projects. These partnerships demonstrate the commitment and effectiveness of these organizations in advancing sound management and understanding of NPS geologic resources. Particularly noteworthy in 2005 was the strengthening of the partnership with the USGS by facilitating joint project development, supporting targeted USGS science in parks, and directing the National Cooperative Geologic Mapping Program toward park applications. Moreover, the USGS "Understanding the Appalachians" workshop brought in $75,000 for mutually beneficial projects. In addition, the division initiated a promising partnership among local geologic societies and parks, with a pilot effort between the Rocky Mountain Association of Geologists and Great Sand Dunes National Park (Colorado), which has already provided useful education and resource management products.

Finally, as an advocate for the addition of geologic expertise at all levels of the National Park Service, GRD staff worked with parks to increase the number of dedicated geology-related positions across the National Park System from fewer than 70 in 1995 to approximately 100 in 2005, partly as a result of funding increases under the Natural Resource Challenge initiative. The specialists in parks and regions manage projects and collaborate with external organizations to facilitate understanding of park geologic resources and natural system interactions, resulting in improved management decisions and delivery of better public information. The addition of Natural Resource Challenge–funded positions within the division has enabled it to broaden the range of geologic expertise it offers in support of parks and to take on more projects. ■

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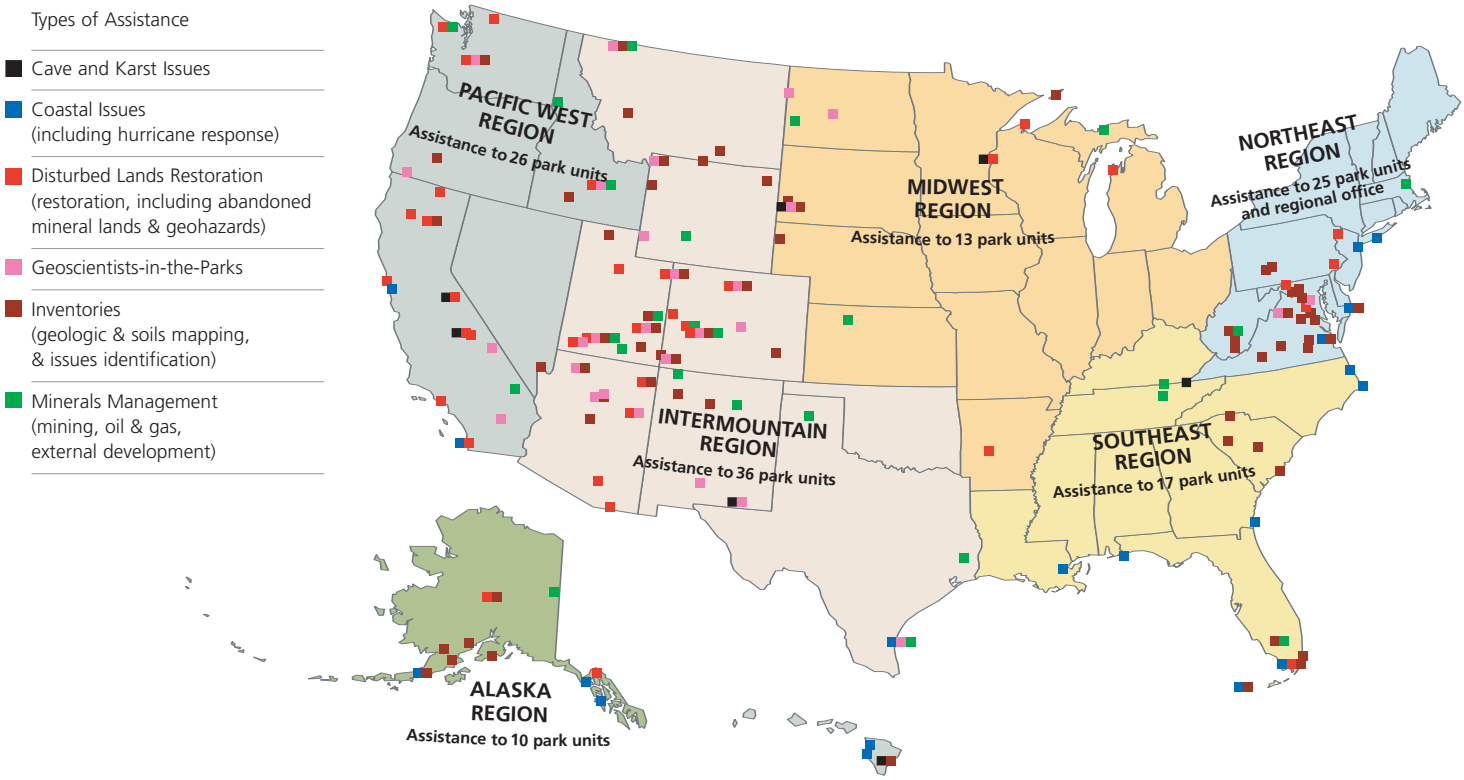
GEOLOGIC RESOURCES DIVISION ASSISTANCE TO PARKS, FY 2005 (PARTIAL LIST)



# Canon Scholars: Training the next generation of conservation scientists

*By Jean McKendry and Gary Machlis*

**THROUGHOUT THE WORLD** a better understanding of how to preserve the natural and cultural resources of national parks for future generations is urgently needed. Hence there is a vital responsibility to educate and prepare the next generation of conservation scientists.

Established in 1997, the Canon National Parks Science Scholars Program is developing this next generation of scientists working in the fields of conservation, environmental science, and national park management. The program annually awards eight scholarships to support the education and research expenses of doctoral students for three years. Students are selected from disciplines in the biological, physical, social, and cultural sciences, and technology innovation in support of conservation science. The program is underwritten and supported by Canon U.S.A., Inc., in a collaborative partnership with the American Association for the Advancement of Science (AAAS) and the US National Park Service (NPS). Gary Machlis, NPS visiting senior scientist, directs the program.

In 2005 the program produced a special report titled "The Canon National Parks Science Scholars Program: Training the Next Generation of Conservation Scientists." This report describes how the program operates, including the contributions of the partners; introduces both past and present Canon Scholars; and highlights many of the parks where their research has been conducted or is under way. It also includes a bibliography of selected scientific articles and presentations they have made and is available on the Internet at http://www.nps.gov/pub_aff/csp_report/index.html.

As the report describes, the program achieved the following from 1997 to 2005:

- More than 60 PhD students have become Canon Scholars.
- Canon Scholars come from seven countries and 46 universities; 64% are women.
- Canon Scholars have conducted or are doing research in 78 national parks, 50 of which are in the United States.
- More than 225 scientific articles have been authored or coauthored by Canon Scholars.
- Canon Scholars are working as tenure-track professors, postdoctoral scientists, park managers, environmental organization professionals, and government scientists.

With the selection of the ninth class of scholars in 2005, the program continues its commitment to the NPS goal of "parks for science" and "science for parks." NPS Director Fran Mainella said: "The Canon National Parks Science Scholars Program is one of the most inspiring programs our agency is privileged to be a part of. This significant partnership … provides research that is vital to the preservation and understanding of national park resources." The 2005 Canon Scholars are studying in national parks from Canada's Tuktut Nogiat National Park (Northwest Territories), to Florida's Everglades National Park, to Chile's Chiloe National Park.

Park managers throughout the Americas are benefiting from this research. At Virgin Islands National Park, Rikki Grober-Dunsmore (class of 2002) conducted research on using large-scale ecosystem patterns and habitat features to predict reef fish abundance and diversity. Her findings are important for developing effective management strategies to protect coral reef ecosystems worldwide. In Yosemite National Park, Jessica Lundquist (2002) measured the magnitude and timing of daily fluctuations in streamflow in relation to the location and rate of snowmelt in a river basin. Her findings yielded a better understanding of where and when snow melts and how it travels through the river network. These findings are critical in light of the potential impacts of global warming on snowmelt processes.

*Canon Scholars have conducted or are doing research in 78 national parks, 50 of which are in the United States.*

At Organ Pipe Cactus National Monument, Colleen O'Brien (2005) is documenting the historical and present-day connections of desert people to the area's natural resources. One result of this effort will be integrating a biocultural component into threatened and endangered species monitoring programs. At the Great Dismal Swamp National Wildlife Refuge, part of the NPS Underground Railroad Network to Freedom, Daniel Sayers (2004) is studying how African Americans used the swamp to escape slavery in the South prior to the Civil War. His findings will provide information relevant to the conservation and interpretation of this and related sites in the Underground Railroad Network.

In addition to funding dissertation research, the Canon Scholars Program provides leadership training, professional development, and opportunities to share research findings. Students join a community of scholars and develop a deeper understanding of conservation through activities of the program. In 2000 a retreat was held in Big Sky, Montana, and Yellowstone National Park, focusing on the relationship between science and the media. Presentations were given by professionals from Canon U.S.A., Inc., members of the media, and representatives of the National Park Service. Pulitzer Prize–winning author and journalist William Dietrich gave the keynote presentation. Canon Scholars, working with Canon and media professionals, practiced communicating science findings to the general public. They also toured Yellowstone National Park, met with park staff, and learned about the national vision for Yellowstone.

Science symposia were held in Williamsburg, Virginia, in 2000 and in Washington, DC, in 2001. The program sponsored a special


The 2002–2004 classes of Canon National Parks Science Scholars assembled in Danzante, on the Sea of Cortez in Baja California Sur, Mexico, in April 2005 as part of an annual retreat to enrich their studies of conservation, including national park management issues.

youth session at the Fifth World Parks Congress in South Africa in 2003. Vieques, Puerto Rico, was the location of the 2003 retreat, which focused on the ecological restoration of lands and waters formerly used for military training. The 2005 retreat was held at Danzante, an ecotourism facility on the coast of the Sea of Cortez in Baja California Sur, Mexico. Its purpose was to learn about the region and an ecosystem critical to global conservation. The group met with representatives of the newly created Bahia de Loreto National Park as well as with leaders of local communities and conservation groups.

Each Canon Scholar brings a unique perspective, background, and insight to critical park issues. Each class of scholars expands the capacity of science to help conserve and protect national parks. Collectively the work of Canon Scholars—the next generation of conservation scientists—and the collaboration among Canon U.S.A., Inc., the AAAS, and the National Park Service will contribute to the advancement of science and create solutions for improving the management of national parks in the 21st century. ■

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# Partnership between National Park Service and National Geographic Society under way

*By Diana Maxwell and Pamela Underhill*

**THE PARTNERSHIP PROGRAM** of the NPS Natural Resource Program Center brought together the National Park Service and National Geographic Maps (a division of the National Geographic Society) to sign a formal partnership agreement in November 2004. That agreement was the culmination of five years of collaboration and has the potential for a fruitful partnership between the two organizations that should help each to fulfill its mission. In particular, the National Park Service is excited about the prospects for a rich exchange of information and technology in order to develop communication vehicles that will help it engage the public more effectively in a variety of park management issues and educational opportunities.

*The National Park Service is excited about the prospects for a rich exchange of information and technology.*

The first products of the partnership are coordinated National Park Service–National Geographic Web sites focusing on Civil War history and geography that were launched in April 2005 (http://cwar.nps.gov/civilwar/ and http://java.nationalgeographic.com/maps/civilwar/). The Park Service site explores the social, economic, political, and military aspects of the war; the related units of the National Park System; battlefield protection; and the roles of African Americans in the war. It also presents a searchable database of soldiers and sailors who served in battle and shares materials for education about the war. The National Geographic site features "MapMachine," an interactive mapping utility that allows users to explore, print, and save maps of more than 5,200 Civil War battlefields and historic sites. Maps can be tailored to include a variety of GIS layers, showing, for example, the extent of battlefields, modern highways (useful for trip planning), and markers linked to specific information about a site. The maps highlight many units of the National Park System and help users relate history to geography.

A second project stemming from the partnership is just getting started with the goal of contributing to a new era of protection and sustained support for the Appalachian National Scenic Trail. Successful management of this 2,175-mile (3,450-km) footpath, which spans the length of the Appalachian Mountains from Georgia to Maine, requires the participation of thousands of volunteers and multiple jurisdictions of land managers. Following a decades-long land protection effort, Appalachian Trail managers today recognize that long-term protection of the trail depends not only on managing the thin ribbon of protected lands surrounding the footpath but also on fostering positive and collaborative relationships with adjoining landowners and neighboring communities. Engaging these publics


Sixth graders from Harpers Ferry Middle School in West Virginia use GPS units to record the location of the Appalachian National Scenic Trail and other local paths for exploring the town of Harpers Ferry and Harpers Ferry National Historical Park. The students will use the data to produce a brochure for visitors. Like this educational partnership between the National Park Service and the school, a planned partnership with National Geographic Maps strives to foster engaging relationships among trail communities and the 2,175-mile Appalachian Trail itself.


is critical to the sustained stewardship of this national treasure. Two products are envisioned: a geotourism map guide that educates the public about the Appalachian Trail and how it is managed and that guides tourists to key attractions and access points along the trail, and the MapMachine, a robust, interactive, map-based application blending a *National Geographic*–quality supplement-style map with a broad array of Appalachian Trail–specific information that would be available on the Web and at kiosks placed in strategic locations proximate to the trail. These products will combine educational materials and technology to increase awareness of the trail—the richness of its resources, the outdoor recreation opportunities it provides, and its vulnerability—and to foster a conservation ethic that will lead to its sustained stewardship.

Promising programs are now in the works that will offer enhanced and new information to the public about national parks via the Internet. For example, the National Park Service Web site will link to related information about national parks published in *National Geographic Magazine*. With the wealth of articles about national parks in this renowned publication, Web users will benefit greatly from this added feature. Additionally, the National Park Service and National Geographic Maps are exploring new avenues for technology transfer, including equipment, GIS programs, and mapping products to help park staffs manage their fire and law enforcement responsibilities. In 2006 the National Park Service hopes to broaden the partnership to include National Geographic publications. ■

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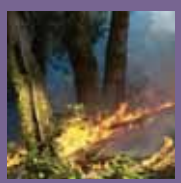
# 2 Integrated Science for Resource Management and Planning

Gone are the days when national parks were managed mostly for their scenic values, individual species of large animals, and various curiosities. Early park

management generally did not appreciate the interdependence of park natural resources or recognize how strongly they depend on the larger landscape. Today, heritage values of ecosystems have joined recreational and other values of parks in guiding stewardship. Prudent management of these values is based on science and strives to integrate multiple disciplines to give as complete a picture as possible of the condition and function of park natural resources. This trend to gain a more holistic understanding of park resources and

to view them in the ecological context of the modern landscape is reflected in the articles that follow. They describe numerous approaches to natural resource management that integrate various biological and physical science components in addition to land use history. They demonstrate the tremendous value of collaboration and teamwork,

the utility of synthesizing data from isolated studies, and the importance of focusing the right expertise on information gathering, analysis, and application to inform park management. Whether reporting work of the monitoring networks, cooperative ecosystem studies units, park staffs, or other entities, the articles suggest a level of sophistication—clearly beyond single-species management—that is appropriate and necessary for addressing challenges to preserving park



the complexity of contemporary natural resources.

*"Americans are witnessing a paradigm shift in national park conservation and management.... Conservation strategies now recognize the need to include people as part of the system and to address cause, rather than symptoms, of system dysfunction by managing whole ecosystems, not just single species."* — **William L. Halvorson and Gary E. Davis**

# Determining risk of airborne contaminants to western national parks

*By Tamara Blett*

**WHAT DOES *INTEGRATED SCIENCE* MEAN?** In the National Park Service, it may mean an alphabet soup of "ists" and "ologists" who have come together for the Western Airborne Contaminants Assessment Project (WACAP). Biogeochemists, analytical chemists, toxicologists, limnologists, hydrologists, ecologists, plant physiologists, atmospheric scientists, fisheries pathologists, and fisheries endocrinologists are working as an integrated team to conduct environmental detective work on toxic compounds in eight western national parks. The Environmental Protection Agency, US Geological Survey, USDA Forest Service, Oregon State University, and University of Washington are working in partnership with the National Park Service (NPS) on this assessment.

*An alphabet soup of "ists" and "ologists" … have come together … as an integrated team to conduct environmental detective work on toxic compounds in eight western national parks.*

Specifically, this six-year project is designed to determine (1) if contaminants are present in western national parks, (2) where contaminants are accumulating (geographically and by elevation), (3) which contaminants pose a potential ecological threat, (4) which indicators appear to be the most useful to address contamination, and (5) the sources for contaminants measured at the national park sites. Very little information is available about the presence, distribution, and effects of contaminants in ecosystems in the western United States. Biomagnification, a process by which contaminants build up in ecosystems to a greater extent at higher levels of the food chain, is of particular concern in parks because of congressional mandates to protect parks unimpaired for future generations.

What are the challenges with integrating so many specialists into a cohesive project? Twice-yearly coordination meetings are held to keep everyone on track and to develop joint strategies for data sharing and collaborative analysis of results. A "science coordinator" for the project keeps the study on schedule and facilitates study design development, communication, reporting, and publication. A "logistics coordinator" deals with fieldwork planning for the team, database development, and quality assurance planning for all investigators in the group. A "project coordinator" provides program goals, communicates project milestones within the National Park Service, pulls together multisource funding, and deals with budgets and interagency agreements. Funding for the project is also integrated across a variety of sources: 23% from partners, 22% from the NPS Air Resources Division, 22% via the NPS Natural Resource Challenge, 21% through the NPS competitive Servicewide Comprehensive Call, 6% from park Recreational Fee Demonstration Program sources, 4% from NPS Inventory and Monitoring, and 2% from the NPS Water Resources Division.

Researchers from Mount Rainier National Park and the USGS sample snow, one of six ecological components being analyzed for contaminants as part of WACAP. The program enhances scientific understanding of the global transport of airborne contaminants and their associated effects on sensitive ecosystems in eight western national parks.

The information gathered as a part of this multiagency partnership project is of great value to the National Park Service because it manages an abundance of arctic and alpine ecosystems. This information is particularly important in these cold ecosystems where many types of toxic contaminants are more likely to condense out of the atmosphere and deposit.

Early results of this integrated team project show that some currently used chemicals, as well as others that are now banned in the United States, are present in high-elevation areas of western national parks. This is especially true in parks near agricultural areas. Agricultural pesticides, industrial by-products (PCBs), and flame-retardant coatings for fabric (PDBEs) have been detected in snow, vegetation, and fish in several of the parks where analysis has been completed. Final results of the study will be published in 2007. ■

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# Integrated biological approach generates recovery of island foxes at Channel Islands

*By Tim Coonan*

**IN ORDER TO PREVENT THE EXTINCTION** of three subspecies of the endangered island fox (*Urocyon littoralis*) from San Miguel, Santa Cruz, and Santa Rosa Islands at Channel Islands National Park, California, the National Park Service brought together experts from a variety of biological disciplines. The integrated biological approach has resulted in a recovery milestone: the reestablishment of wild fox populations on San Miguel and Santa Rosa Islands and an increase in the Santa Cruz population to more than 200 foxes. Local zoo personnel helped develop husbandry methods (e.g., diet, pen design, and hygiene). Wildlife and zoo veterinarians, and wildlife pathologists and parasitologists developed a program of veterinary care in particular methods to mitigate the effects of disease and parasites. Genetic experts identified the relationships among captive foxes, established the pedigree, and together with captive breeding specialists designed a breeding program with guidelines for annual pairing. Bald eagle (*Haliaeetus leucocephalus*) and golden eagle (*Aquila chrysaetos*) experts developed removal methods for golden eagles, which had never bred on the islands before the 1990s. Experts in population modeling estimated the number of captive foxes that would need to be released annually to recover wild populations to viable levels within a decade. Working backward from these estimates, the recovery team determined the optimal size of the captive breeding program as 20 pairs on each island.

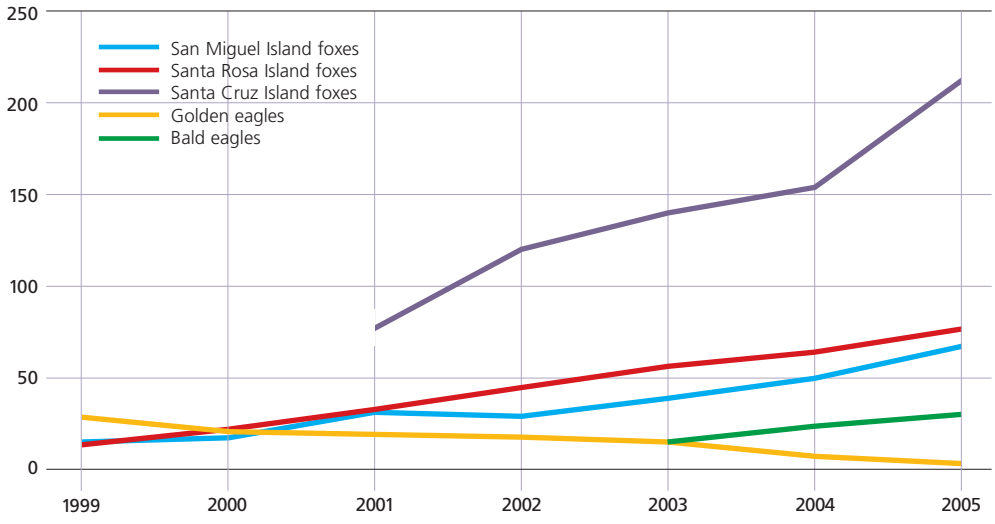
Demographic modeling provided a glimpse into the nature of interactions between golden eagles and their island prey species. From 1995 to 2000, island fox populations on San Miguel, Santa Cruz, and Santa Rosa Islands declined by as much as 95% because of predation by golden eagles. Modeling adequately supports the notion that island foxes would not be threatened with extinction today if feral pigs (*Sus scrofa*) had not been on Santa Cruz Island to support golden eagle breeding. In addition the absence of bald eagles, which were extirpated from the islands by 1960 because of organochlorine poisoning, facilitated golden eagle colonization of the islands. Bald eagles specialize in marine prey and do not take island foxes. Had bald eagles still been present in the latter half of the 20th century, they might have prevented the establishment of golden eagles, which take terrestrial vertebrate prey. Moreover, island fox decline allowed its only competitor, the endemic Santa Cruz Island spotted skunk (*Spilogale gracilis amphiala*), to increase to unprecedented population levels. Skunk abundance is once again beginning to tail off as island foxes increase in the wild.

Release of island foxes into the wild is a significant milestone for the island fox recovery program at Channel Islands National Park. However, release was realized only through an integrated biological approach that involved removal of feral pigs, relocation of golden eagles, and reintroduction of bald eagles to the northern islands. Six subspecies of island fox are distributed on the six largest of the Channel Islands, one subspecies per island.

Because predation by golden eagles is the only significant source of mortality for island foxes on the northern Channel Islands, eagle removal has been very effective at increasing fox survivorship and fostering population recovery. Since 1999, raptor biologists have captured 41 golden eagles from the northern Channel Islands and relocated them to mainland California. No relocated eagles have returned. The

RECOVERY OF ISLAND FOX 1999–2005, CHANNEL ISLANDS NATIONAL PARK

As wildlife biologists have removed feral pigs, relocated golden eagles, and reintroduced bald eagles, the number of endangered island foxes on San Miguel, Santa Rosa, and Santa Cruz Islands has increased, indicating they are on the road to recovery. Decline in the number of feral pigs is not included on the graph because recovery efforts did not record such data with any level of confidence; however, park staff estimates that 5,000 pigs inhabited the islands before removal efforts, with approximately 2,500 remaining at the end of 2005. Contractors will have removed the bulk of these remaining animals by summer 2006.



success of eagle removal is measured by the survival of wild island foxes on Santa Cruz Island. In 2005, annual survival of wild island foxes increased to well over 80%—the level determined by demographic modeling to be required for recovery.

From the beginning, the National Park Service championed an ecosystem approach to island fox recovery, which required the long-range actions of feral pig removal and bald eagle restoration and the short-term, species-specific actions of fox captive breeding and golden eagle removal. This integrated approach—which coordinated multiple agencies, academics, and nonprofits in what appeared to be a single-species management program by a single agency—garnered the necessary expertise for recovery of this heretofore poorly understood species. As of 2005 the total population of foxes on San Miguel was 67 (up from 15 in 1999), 77 on Santa Rosa (up from 14 in 2000), and 210 on Santa Cruz (up from 65 in 2000).

The Nature Conservancy, co-owner with the National Park Service of Santa Cruz Island, has proved an ideal neighbor, becoming a full partner in removal of pigs and golden eagles and in captive breeding of island foxes. The Nature Conservancy has contracted for pig removal, which began in spring 2005. The operation has quickly moved across the island and removal has begun on NPS property. Contractors removed about half the estimated 5,000 pigs in 2005 and will remove the bulk by summer 2006. At that time the island will be relatively free of pigs for the first time in more than 150 years.

The National Park Service is also cooperating with other agencies in an effort to reestablish bald eagles on the northern Channel Islands. Monies from the settlement of an environmental contamination case are funding annual release of up to 12 young bald eagles on Santa Cruz Island from 2002 to 2006. By the end of FY 2005, approximately 30 bald eagles remained on Santa Cruz Island from previous releases. Bald eagles mature at four or five years of age, so eagles from the first releases in 2002 may establish territories and attempt to breed in 2006.

Faced with the likely extinction of three island fox subspecies, the National Park Service began implementing recovery actions for island foxes on the northern Channel Islands in 1999. Although the Park Service has taken the lead in recovery actions for the three listed subspecies in the north, collaboration has characterized the effort from the beginning. A variety of project funding sources have supported fox recovery, including Natural Resource Preservation Program funding, 20% Recreational Fee Demonstration Program monies, and settlement funds from chemical contaminant cases. In FY 2005, Channel Islands National Park received a base increase of $477,000 from the Natural Resource Challenge for fox recovery. This base funding puts the recovery efforts, which are estimated to take as long as a decade, on firm financial ground for the duration of the program. ■

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## Integrated management strategies used to protect cultural landscape of Bald Hills

*By Terry Hofstra*

**DID YOU EVER THINK OF GRASSLAND** as a cultural resource, something not unlike rock art or a historical dwelling? People shape the environment today, so it is in many ways unsurprising that Native Americans also influenced the landscape they inhabited for thousands of years. For example, Native Americans used fire to maintain prairie grasslands and oak woodlands in the Bald Hills of California. Today, modern fire suppression efforts and the invasion of nonnative plant species have resulted in the dramatic decline of these uncommon landscapes. Redwood National and State Parks is integrating both natural and cultural resource management strategies to protect the cultural landscape of the Bald Hills. In 2005 this effort resulted in the treatment of more than 2,000 acres (810 ha).

The elimination of Native American cultural use of fire and the control of wildfires allowed Douglas-fir (*Pseudotsuga menziesii*) trees to propagate and grow unchecked in the Bald Hills. These rapidly growing trees steadily encroached onto the prairies and oak woodlands, totally shading and eliminating native vegetation. For example, more than 85% of one prairie has been lost to Douglas-fir encroachment since 1829, when explorer Jedediah Smith recorded in his journal that his entourage camped there.

This landscape has also been assaulted by the intentional introduction of nonnative pasture grasses and other plant species. Two examples of harmful nonnative plants of special concern are tall oatgrass (*Arrhenatherum elatius*) and Scotch broom (*Cytisus scoparius*). Monitoring has shown that these plants have the ability to outcompete and suppress native plants. These invaders also have the potential to seriously impact the Bald Hills Roosevelt elk (*Cervus elaphus* subsp. *roosevelti*) population. A yearlong study of the diet of the elk, which was conducted by analyzing pellets, showed that the elk were not eating tall oatgrass. Likewise, large areas of Scotch broom, which forms dense brush fields up to more than 6 feet (1.8 m) tall, diminish habitat for grazing animals.

Redwood National and State Parks managers have implemented a combination of natural and cultural resource management strategies to combat these challenges and preserve native grasslands and oak woodlands and their dependent wildlife. By restoring fire to the Bald Hills, park managers are able to kill smaller Douglas-fir trees. Trees too large to be killed by prescribed fires are manually cut with chainsaws. In 2005 the park conducted prescribed burns on more than 2,000 acres (810 ha) of the Bald Hills and cut approximately 70 acres (28 ha) of large, fire-resistant Douglas-fir trees.

Park research has shown that prescribed burning in spring can control tall oatgrass and Scotch broom as well as other aggressive nonnative plants. However, this research also indicates that spring burning negatively affects the important native California oatgrass (*Danthonia californica*); therefore, burning has been restricted to the fall. Monitoring shows that tall oatgrass has been held in check to

The elimination of Native American cultural use of fire and modern fire suppression efforts have allowed Douglas-fir trees to steadily encroach onto the grassland prairies and oak woodlands of the Bald Hills. By restoring fire to the park, the National Park Service is able to kill smaller Douglas-fir trees in areas like Coyote Creek (pictured here). In 2005 this effort resulted in the treatment of more than 2,000 acres (810 ha).

Burns in ethnographically significant areas are conducted with sensitivity to the importance of these resources to the local Yurok Tribe. For example, individual large tanoak (*Lithocarpus densiflorus*) trees, which were tended and used for centuries by the Yurok as a source of acorns, are protected from fire.

date by this management program. However, the strategy for reducing Scotch broom involves removing the mature plants manually, followed by fall burning and subsequent control of seedlings and root sprouts.

Cultural resource protection activities have been undertaken in cooperation with the Yurok Tribe. Over the years, tribal members have provided important ethnographic information about the entire Bald Hills region. Yurok tribal staff has also conducted postfire monitoring of important archaeological and ethnographic resources through task agreements that are part of the tribe's self-governance compact with the National Park Service. Burns in ethnographically

*The prairies and the surrounding oak woodlands are now managed as natural components of a cultural landscape, reflecting the complex interactions of human and nonhuman activities.*

significant areas are conducted with sensitivity to the importance of these resources to local tribes. For example, measures are taken to protect individual large tanoak (*Lithocarpus densiflorus*) from fire. These same oak trees were tended for centuries by the Yurok, who used fire as a tool to maintain the health of the trees and thereby ensured successful acorn harvests. Additionally, historical structures and cultural landscape districts, archaeological districts, and ethnographic resources are being stabilized and protected.

Public education is also an important facet of the program. To increase public understanding of the use of fire and the need to protect this landscape, the park has invited the public to observe the prescribed burns and attend special educational field trips with park staff. The public has enjoyed the on-site discussions and the opportunity to closely but safely observe fire operations and understand management goals.

An integrated program to restore the prairies and oak woodlands has been evolving since the mid-1980s, when experimental work and pilot programs were first initiated. After the program took shape, more than 10 years of intensive management effort focused on restoring these important landscapes. The effort has paid off. The prairies and the surrounding oak woodlands are now managed as natural components of a cultural landscape, reflecting the complex interactions of human and nonhuman activities. As a result, these uncommon landscapes are beginning to make a comeback. ■

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# Parks complete vital signs monitoring plans

*By Pete Penoyer, Dean Tucker, Gary Rosenlieb, Barry Long, and Roy Irwin*

**MANY AMERICANS WOULD BE SURPRISED TO LEARN** that 118 national park units that contain one or more bodies of water do not meet state water quality standards for one or more pollutants. For example, fecal-indicator bacteria impair recreational uses in 53 parks. Recognizing that solutions to water quality problems may require years of targeted effort, the National Park Service (NPS) is making progress toward understanding key water quality trends and conditions. In 2005 the first 12 networks completed their plans for water quality monitoring as part of a program of tracking resource conditions that began in 1999 with the inception of the Natural Resource Challenge initiative.

Water quality is just one of 12 broad "vital sign" components that have been selected for monitoring by the National Park Service. Each vital sign is a measurable indicator of change in the condition of key park resources and serves as an early-warning signal of possible long-term impairment of natural systems. To undertake Servicewide monitoring, the more than 270 natural resource park units have been organized into 32 monitoring networks. Now in their third year of planning and funding, the first 12 funded monitoring networks have successfully completed phase 3, the final stage, of monitoring plan development for water quality under the vital signs program. The process for developing monitoring plans was created in conjunction with the NPS Natural Resource Program Center. These 12 monitoring networks encompass 101 natural resource park units and represent over one-third of the more than 270 parks in 32 planned networks that are expected to develop monitoring plans.

Each network's water quality monitoring plan links the monitoring of individual parks to the federal-state regulatory framework established under the Clean Water Act. For example, the San Francisco Bay Area Network formulated its plan by first examining the beneficial uses of its water bodies as defined by the act and how these designations interact with state water quality standards. Common beneficial uses of water include recreation, aquatic life (including fisheries), public water supplies, and industrial and agricultural activities. A violation of water quality standards can occur when any narrative or numeric criterion is acutely exceeded or when designated uses are shown to be chronically affected adversely by human activities. The network then addresses the specific ecological water quality issues related to individual parks.

The first 12 networks to complete the water quality monitoring plans have made significant and highly useful contributions in sampling design, protocol development, and identification and selection of field and laboratory methods. Similarly, these networks have addressed many challenges related to data handling, analysis, and reporting procedures as they have finalized their planning efforts. The Cumberland Plateau Network, in particular, has demonstrated

In 2005, more than 100 national park units completed their plans for water quality monitoring. The Northeast Coastal and Barrier Network is working collaboratively with staff at the Assateague Island National Seashore, Maryland and Virginia, to develop an estuarine monitoring program that will address management issues of interest to both the park and the network. Pictured here is Sarah Sand, a seasonal park employee, collecting water quality data at Assateague Island National Seashore.

In 2005, NPS staff with the Greater Yellowstone Network participated in a training program at Bighorn Canyon National Recreation Area, Montana and Wyoming, to familiarize themselves with the latest multiparameter water quality monitoring instruments. Training on instrumentation is important because the technology changes rapidly. The NPS staff member pictured is measuring core water quality parameters for a cross section of the stream.

Marcus Johnson, resource management specialist at Shiloh National Military Park, Tennessee, collects a water sample from Owl Creek, which is on the park's western boundary. The sample will be analyzed for temperature, pH, specific conductance, dissolved oxygen, acid-neutralizing capacity, nitrate, and bacteria. Park staff works cooperatively with the Cumberland Piedmont Network to conduct water quality monitoring.

leadership in the acquisition of data and has already begun reporting to the NPS Water Resources Division new water quality information for its parks. These advances will save time and resources for the networks that will follow in their footsteps.

These examples highlight the focus and emphasis of the monitoring design process: monitoring must be driven by "measurable objectives," have an "identified target population," and provide sufficient accompanying metadata to be useful. Additionally, the questions formulated by the network must be resolvable using established USGS, EPA, or state protocols. Data must also be subject to rigorous quality assurance and quality control to ensure comparability with other data sources. With an eye to the future, the National Park Service has taken extensive measures not only to ensure that its data are comparable with those of other agencies, but also to encourage universities, watershed councils, and other volunteer groups conducting monitoring to document sufficient metadata.

Data capture, compilation, management, and sharing will be accomplished on a Servicewide basis using NPSTORET and NPS EDD (www.nature.nps.gov/water/infoanddata/index.htm). The data will then be funneled into the EPA's STORET National Warehouse (http://www.epa.gov/storet/dw_home.html). Storing data gathered from all 32 networks in the EPA database will assist parks, the Water Resources Division, and the Inventory and Monitoring Program in responding to issues requiring the Servicewide synthesis and analysis of water quality information, as required by the Government Performance and Results Act (GPRA).

Under the vital signs monitoring program, NPS water quality monitoring for the first time has a cohesive national structure. This structure is important because it will ensure that monitoring can help parks identify tangible management actions, achieve restoration and cleanup, and assess progress toward the attainment of NPS GPRA goals. Water quality monitoring plans represent the first step toward comprehensively addressing the water pollution and emerging contaminant issues that challenge national parks across the United States. ■

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# Watershed assessments enhance cooperative coastal conservation

*By Cliff McCreedy and Kristin Keteles*

**WATERSHED ASSESSMENTS THAT INTEGRATE** the physical and biological sciences—including oceanography, water quality, marine and estuarine sciences, and geographic information systems (GIS)—are improving scientific understanding of coastal resources in the National Park System and revealing factors that may cause impairment. As of FY 2005, the NPS Water Resources Division (WRD) has initiated assessments of 41 ocean and Great Lakes parks through the Watershed Condition Assessment Program. Working with member universities of Cooperative Ecosystem Studies Units (CESUs), WRD staff plans to complete assessments of 52 ocean and Great Lakes parks. The Water Resources Division also coordinates closely with park managers and the NPS Inventory and Monitoring (I&M) networks to integrate coastal assessments into park and Servicewide databases and plans for monitoring vital signs, key indicators of ecological condition.

During the assessment process, scientists review and synthesize existing information to determine the condition of coastal park resources, including water quality, habitat status, invasive and feral species, extractive uses, and physical impacts from resource use and coastal development. Since FY 2004, assessments have incorporated geospatial information using GIS databases and maps, which facilitate evaluation of resource condition. In addition, GIS-based assessments are informational tools for reporting to strategic "land health" goals under the Government Performance and Results Act. Assessments cover all habitats, including upland, riparian, wetland, and coastal and marine areas.

Reports from coastal assessments identify information gaps that require further study and obstacles that hinder resource management efforts. For example, at Cumberland Island National Seashore, Georgia, investigators found low concentrations of dissolved oxygen in surface waters during summer months. This discovery has already resulted in increased attention by the State of Georgia concerning the potential for hypoxia in the Cumberland Sound and the need for additional monitoring. Hypoxia—critically low levels of dissolved oxygen that can harm populations of fish and invertebrates—is a condition linked to high levels of nutrients and algal blooms. Other potential threats to Cumberland Island's water resources are toxic compounds, metals, and invasive species.

*The National Park Service needs to know the condition of coastal water resources in and around parks in order to address problems cooperatively.*

Watersheds that drain into the coastal zone are dynamic hydrologic systems that create and sustain coastal ecosystems. Watershed

The Klamath River empties into the Pacific Ocean at Redwood National Park, California, where a coastal watershed condition assessment raises concerns about sediment runoff affecting park marine resources. The study is one of 41 assessments under way as of FY 2005 at ocean and Great Lakes units of the National Park System to evaluate resource conditions and identify information gaps that require further study to support resource management efforts.

health determines sediment flow, water quality, salinity, and other factors affecting aquatic ecosystems. With more than 55% of the US population now living within 60 miles (97 km) of a coast, this relatively high population density and the consumption of resources are taking their toll on coastal ecosystems. Coastal areas face many threats that could have dramatic impacts on the function and integrity of coastal park ecosystems, including:

- Coastal wetlands losses—more than 20,000 acres (8,100 ha) per year
- Water quality problems—harmful algal blooms, salinity changes, hypoxia, toxic pollutants, and eutrophication (nutrient enrichment leading to depletion of dissolved oxygen)
- Overfishing and recreational overuse
- Coastal development, unnatural shoreline change, and sediment flow alterations

The National Park System has more than 5,000 miles (8,045 km) of coast, including coral reefs, barrier islands, kelp forests, estuaries, and other ocean and Great Lakes resources. These coasts and the 74 national parks they contain attract more than 76 million visits each year. Hence the National Park Service needs to know the condition of coastal water resources in and around parks in order to address problems cooperatively with states, local entities, watershed councils, and park stakeholders.

By using common parameters and assessment methodologies, the Watershed Condition Assessment Program is collaborating with the US Environmental Protection Agency's National Coastal Assessment (NCA) Program. Park staffs, I&M networks, and the Water Resources Division are already using data and sampling protocols from the NCA Program. When assessments are complete for coastal parks in the vital signs networks, the NCA Program will provide information on regional conditions with which to elucidate and compare park conditions. Furthermore, these assessments are stimulating scholarly interest of coastal parks and increasing local partnerships with CESU universities. Though coastal parks are not immune to the problems plaguing the coastal zone, integrated watershed assessments are helping managers identify and tackle threats to coastal ecosystems. ■

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# A watershed approach to coral reef management at War in the Pacific

*By Dwayne Minton*

**INCREASINGLY, NATIONAL PARK** and natural area managers and scientists are recognizing that ecosystem conservation must be conducted with a holistic perspective, looking not at artificially contrived compartments but at ecologically significant units, such as watersheds. Nowhere is this more apparent than in marine resource management, where threats often have an external terrestrial origin and their sources are difficult to identify and isolate. As a result, effective management of our coastal resources must start not at the low tide line but at the top of the mountains. Managers at War in the Pacific National Historical Park are taking this approach to coral reef conservation.

*Effective management of our coastal resources must start not at the low tide line but at the top of the mountains.*

Located on Guam, War in the Pacific protects more than 1,000 acres (405 ha) of Indo-Pacific coral reef, which is home to more than 3,500 species of marine plants and animals. Park reefs are threatened by numerous land-based environmental problems, including pollution, overharvest, and poorly regulated land development and recreational activities. One of the most severe impacts to park reefs is nearshore sedimentation. An estimated 27,558 tons (25,000 metric tons) of sediment—the equivalent of 20 dump truck loads per day—are deposited onto park reefs each year.

Sediments directly impact corals through burial, but also harm them by reducing water quality, particularly by diminishing light penetration. Without adequate light, reef-building, or hermatypic, corals will die. Park biologists have estimated that sediment loads on park reefs exceed scientifically quantified mortality thresholds for adult coral and also may be contributing to the low rates of new coral recruitment observed by park staff.

Land erosion is contributing up to 80% of the coastal sediments directly affecting park reefs. Though the problem is straightforward,

An NPS diver (left) fans a coral reef at War in the Pacific to reveal the sediments that have settled on and killed the corals at this site in the park. In the picture at right, corals in the lower left corner are dead; those in the upper right are partially dead.

A large wildfire burns through the savanna of the Asan watershed at War in the Pacific National Historical Park on Guam. The burned savannas, a major source of soil loss that contributes to sedimentation on the park's coral reefs (background), have been a focus of a watershed study of illegal wildland fires, erosion, and coral reef sedimentation.

finding a long-term, economically viable solution is a significant challenge. Erosion is not a simple process on Guam, where extreme environmental conditions, coupled with sociopolitical issues, have created an environmental problem that is destroying Guam's terrestrial and marine ecosystems. Frequent, intense storms can drop as much as 20 inches (50 cm) of rain in 24 hours; steep slopes accelerate the loss of highly erodible clay soils, and poorly planned development and frequent wildland arson along with loss of stabilizing vegetation contribute to accelerated soil loss. Park managers need sufficiently detailed information to better target their management actions to achieve the greatest environmental result.

To gain a better understanding of erosional processes contributing to coastal sedimentation, War in the Pacific undertook a two-year, multidisciplinary assessment of the park's watershed, which concluded in June 2005. With funding from the National Fish and Wildlife Foundation and the National Park Service and with help from cooperating soil scientists, botanists, and wildfire specialists, park coral reef biologists have studied the complex interaction of fire and vegetation structure in upland erosion and coastal sedimentation. The results of this work have been used to develop a strategy for reducing coral reef sedimentation through erosion mitigation.

On Guam, wildfire is not a natural process, and illegal wildland arson contributes significantly to erosion. From June 2003 to June 2005, four wildfires burned approximately 3% of the park watershed, resulting in 3,197 tons (2,900 metric tons) of lost soil. Wildfires were found to promote invasive grasses, increasing fire frequency and intensity. As fragile topsoils are lost, underlying, inhospitable clays are exposed. These areas, known locally as badlands, are incapable of supporting vegetation, and while they cover only about 5% of the watershed, they account for up to 6,063 tons (5,500 metric tons, or 22% of the total) of soil loss per year.

Elaborate and costly engineering structures such as sediment basins have been proposed to reduce sediment flushing onto park reefs. These structures, though potentially successful, are expensive, do not address the ultimate problem, and require constant and costly maintenance to be effective. The park study suggests that a better long-term management option is to eliminate illegal wildfires and restore badland areas, potentially reducing soil loss and coastal sedimentation by 34% to a level below thresholds of coral mortality.

Recognizing that it has limited resources to achieve these objectives, the park has maintained close partnerships with territorial agencies and nongovernmental organizations. Using these partnerships, park staff hopes to develop a program of culturally sensitive education and community enforcement that will eliminate illegal wildland arson within the park watershed. The park is also working closely with territorial foresters to develop viable badland restoration techniques to restore these problematic areas. ■

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# Scientific partnerships evaluate coral reef health at Virgin Islands monuments

*By Cliff McCreedy*

**INTERAGENCY PARTNERSHIPS PROVED INVALUABLE** in 2005 as the National Park Service sharpened its scientific focus on the health of coral reefs in "no-take" reserves in two Virgin Islands national monuments. Now that fishing and anchoring are prohibited in these reserves, the National Park Service (NPS) must evaluate how fish, shellfish, and corals are responding to this protection.

Coral reefs are the most biologically diverse marine ecosystems on the planet. On a healthy coral reef, several thousand species interact in complex, interdependent relationships that maintain the ecological balance among fish, invertebrates, and marine plants. Overfishing, anchor damage, pollution, and rising sea-surface temperatures disrupt this delicate balance. The National Park System includes more than 276,000 acres (111,780 ha) of coral reefs in Florida, Hawaii, the US Virgin Islands, Guam, and American Samoa. The most recent additions to the park system are the new Virgin Islands Coral Reef National Monument and more than 18,000 acres (7,290 ha) added to Buck Island Reef National Monument, both established in 2001 by presidential proclamation to restore and maintain coral reef ecosystems.

In the Virgin Islands parks, scientific partnerships and interagency collaboration greatly enhance the parks' capacity to evaluate the extent and condition of coral reef resources. The ecological complexity and variability of coral reefs make evaluation a difficult task that requires an extremely rigorous approach. Several partners, including the NPS Natural Resource Preservation Program, NPS South Florida/Caribbean Inventory and Monitoring Network, individual park staffs, National Oceanic and Atmospheric Administration (NOAA), and US Geological Survey (USGS), work together to develop habitat maps and biological data for park managers.

*In the Virgin Islands parks, scientific partnerships and interagency collaboration greatly enhance the parks' capacity to evaluate the extent and condition of coral reef resources.*

Staff from Buck Island Reef National Monument and scientists with the NOAA National Center for Coastal and Ocean Science Biogeography Program have been mapping submerged habitats and documenting marine species in the expanded Buck Island Reef area using aerial photography, satellite imagery, underwater video cameras, and side-scan sonar on remotely operated vehicles towed by the research vessel *Nancy Foster*. Detailed topographic imagery from the USGS Coastal and Marine Geology Program enhances the maps, which are obtained by aircraft scanning the bottom of the sea with a laser altimeter. The end result is detailed seafloor maps that enable resource managers to identify the extent and variation of different types of coral habitats. Local scientists from the US Virgin Islands Department of Planning and Natural Resources participated in the *Nancy Foster* missions. These efforts continued in 2005 at Buck Island Reef and Virgin Islands Coral Reef National Monuments with funding from the NPS Natural Resource Preservation Program and Geologic Resources Division.

These advanced technological tools provide only part of the picture. To identify marine species using these reefs, divers from the parks, the South Florida/Caribbean Inventory and Monitoring Network, and NOAA make detailed visual surveys of fish and shellfish and measure coral reef habitat. Biologists with the USGS and the National Park Service conduct coral monitoring at both Virgin Islands National Park on St. John and Buck Island Reef National Monument to track coral disease, bleaching and mortality, and long-term coral health.

"These national monuments and the Virgin Islands National Park are highly popular for their beautiful landscapes above and below water," says Craig Manson, Assistant Secretary for Fish and Wildlife and Parks, in 2004. Manson cochairs the US Coral Reef Task Force. "They are mainstays of the tourism economy of the US Virgin Islands. They protect sensitive coral reef areas enjoyed by hundreds of thousands of visitors every year. That is why we must do everything we can to ensure their success." ■

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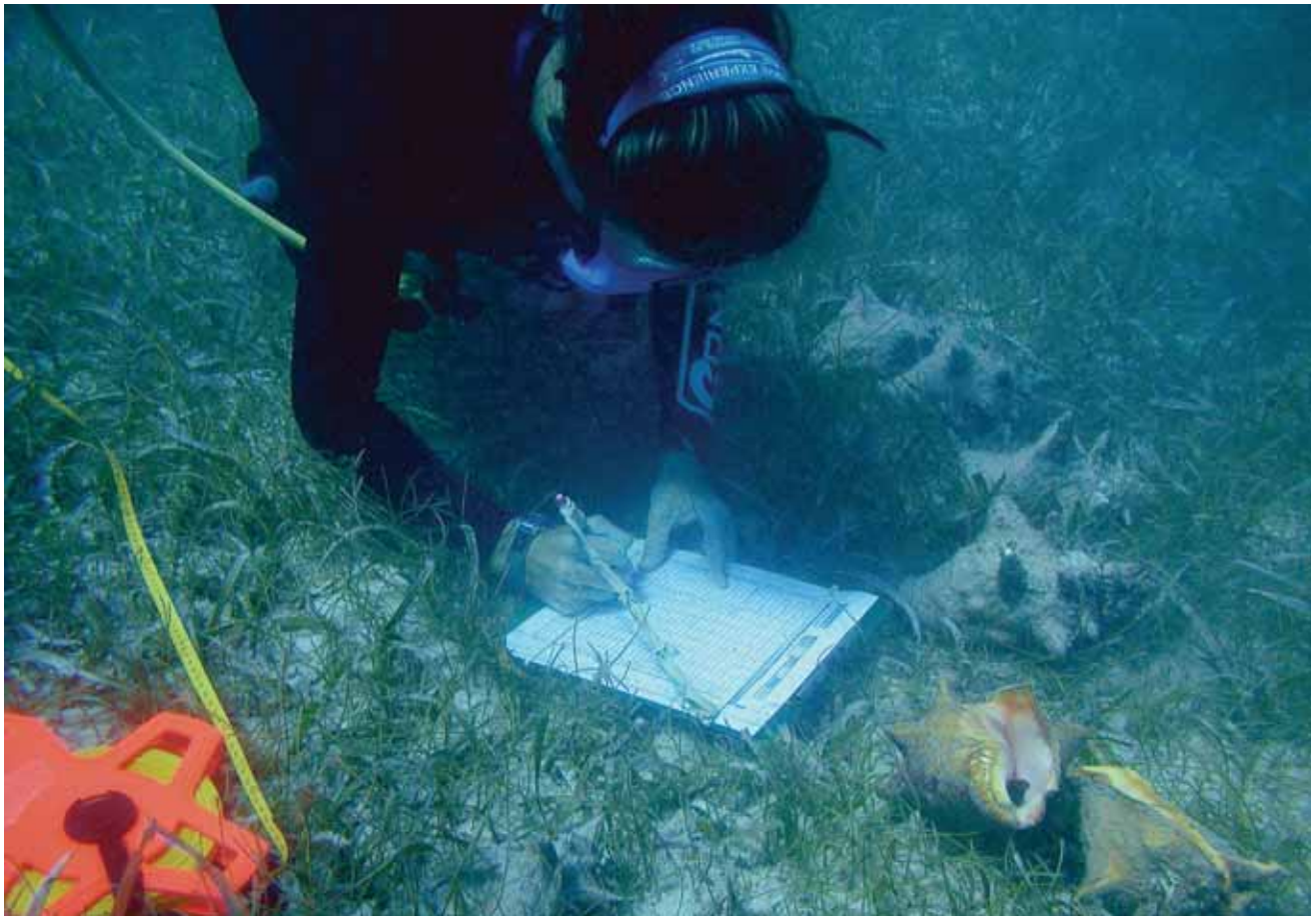
(Facing page, top) Scientists from the National Park Service and other agencies are collaborating to assess fish and coral habitats in a recently established "no-take" marine reserve at Buck Island Reef National Monument, St. Croix, US Virgin Islands, where blue tangs (*Acanthurus coeruleus*), doctorfish (*Acanthurus chirugus*), and ocean surgeonfish (*Acanthurus bahianus*) school.

(Facing page, bottom) An NPS science diver measures the size of queen conchs (*Strombus gigas*) at Buck Island Reef National Monument to document the status and potential recovery of this commercially exploited shellfish in a new "no-take" marine reserve.



# Learning from past research: An aquatic synthesis for Great Lakes Network parks

*By Brenda Moraska Lafrancois and Jay Glase*

**GREAT LAKES AND BIG RIVERS** feature prominently on maps of the upper Midwest, and some of the region's finest aquatic resources are protected as units of the National Park System. The Great Lakes Network of parks consists of two water-based national parks, two riverine parks, four national lakeshores, and a national monument on Lake Superior. In July 2005 the NPS Water Resources Division published an aquatic synthesis technical report that will help the Great Lakes Network develop monitoring strategies, support planning activities at parks, and advance new Watershed Condition Assessment Program projects.

Researchers in these parks have explored chemical and hydrologic attributes of the area's diverse aquatic habitats, studied biota ranging from microbes to moose, and addressed a variety of pressing water resource concerns. To synthesize the wealth of existing information and identify aquatic resource issues, themes, and remaining information needs, the Great Lakes Network and the Midwest Regional Office supported a wide-ranging review of past aquatic studies from 2003 to 2005.

In 2003, regional aquatic professionals collected relevant materials from each of the nine parks and the regional office and discussed aquatic research and monitoring concerns with park and network staff. Baseline Water Quality Data Inventory and Analysis reports, prepared for each park by the Water Resources Division in the 1990s, were also reviewed. In addition to these internal searches, online literature searches were conducted using park names as key words, and publications from state natural resource agencies and the US Geological Survey were reviewed.

*[The] … report … will help the Great Lakes Network develop monitoring strategies, support planning activities at parks, and advance new Watershed Condition Assessment Program projects.*

Studies addressing any aquatic or semi-aquatic organism, habitat, or process qualified for inclusion in the synthesis, and more than 600 studies fit these criteria. General categories of resource topics emerged during an initial review, including water quality, biology and ecology, fish, aquatic wildlife, amphibians and reptiles, wetlands and aquatic vegetation, contaminants, hydrology, groundwater, and physical structure and processes. Studies were placed into one of these categories, and key information from each study (author, publication date, methods, results, and conclusions) was recorded in a summary table. This table became a useful review template for the synthesis.

To serve both park and network needs, two levels of summary and synthesis were performed: park-specific and network-wide. For each park-specific chapter, maps of aquatic resources, basic water resource statistics, and a general summary of previous water studies were provided. Dominant research themes, strengths, and remaining needs were identified, along with specific considerations for future aquatic research and monitoring. The network-wide synthesis followed a similar structure, with an emphasis on common information needs among parks and an exploration of future multipark research possibilities.

Floats mark fish traps at Isle Royale National Park, Michigan, during a recent nearshore fishery survey conducted by the US Geological Survey for the National Park Service. This survey developed information on seldom-studied species in Great Lake Network parks and is one of the many types of research and monitoring efforts referenced in the aquatic synthesis report.

Brook trout restoration efforts are ongoing in several areas around Lake Superior, including three units of the National Park System. Information from this survey and others was included in the fisheries sections of the Great Lakes Network aquatic synthesis report.

Research considerations contained in the document are expected to stimulate development of new research proposals and help communicate park needs to cooperators. Finally, given the breadth of literature included, the synthesis represents a common reference document to be consulted by park managers and shared with interested partners into the future. ■

A copy of the complete synthesis report is available at http://www1.nature.nps.gov/im/units/glkn/reports.htm.

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# Development pressures prompt integration of science and planning to enhance stormwater management in the Cuyahoga Valley

*By Kevin L. Skerl, Jeff Winstel, and Thomas E. Ross*

**IN 2005, TO COMBAT IMPACTS** of increased development on watershed health, park managers at Cuyahoga Valley National Park began urging better stormwater management through environmentally sound community planning. Increased development in areas surrounding the park (i.e., more roadways, buildings, parking lots) has decreased the amount of open land available to absorb surface water. This increased watershed "imperviousness" has, in turn, led to increased runoff and flooding in the area.

*Knowing that development outside the park will likely continue ..., efforts were focused on ensuring that future development is sensitive to environmental concerns.*

The park protects 33,000 acres (13,365 ha) between the cities of Cleveland and Akron, Ohio. It is home to 22 miles (35 km) of the Cuyahoga River and more than 190 miles (306 km) of tributaries (with most watersheds extending out beyond park boundaries). At an ever-increasing rate, the 15 communities surrounding the park have experienced considerable residential and commercial development.

In 2003–2004, the park experienced major flooding, which caused more than $3 million in damages to park infrastructure, recreational facilities, and historical and cultural resources. Many local communities also experienced severe economic impacts from the floods. Although these floods were due to unusually heavy rain, even typical storms are causing floods.

As watershed imperviousness escalates, surface water runoff increases and stream channel erosion and sedimentation occur. These changes result in increased flood frequency and adverse impacts to water quality, habitat structure, and biodiversity. Stormwater management, always an important planning issue, became a priority concern after the floods. Park managers embraced the issue as a unifying theme to engage and educate local communities. Knowing that development outside the park will likely continue despite these adverse effects, efforts were focused on ensuring that future development is sensitive to environmental concerns.

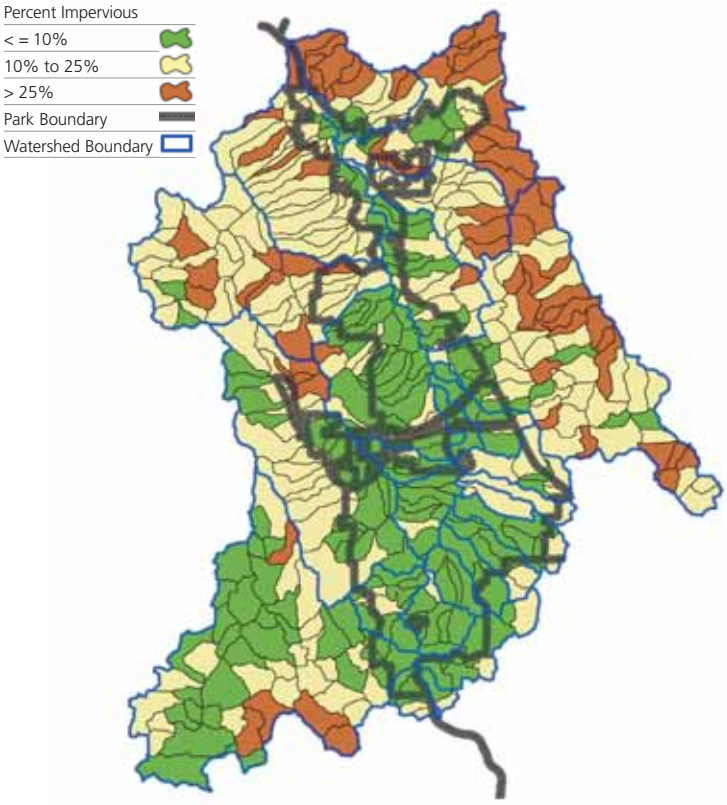
Appropriate development zoning and local ordinances can reduce the impacts of development on watersheds. Such measures include requiring significant open green space (greater than 40%), riparian and wetland setbacks, distributed on-site stormwater management, and protection of steep slopes and sensitive areas. Unfortunately, park managers lacked a comprehensive understanding of existing community zoning regulations. This limited their ability to carry out effective outreach on this issue.

To address this problem an interdisciplinary team was assembled, consisting of an ecologist, a park planner, and a visiting deputy superintendent (on a USDA Graduate School Executive Leadership Program developmental assignment). This team worked together to

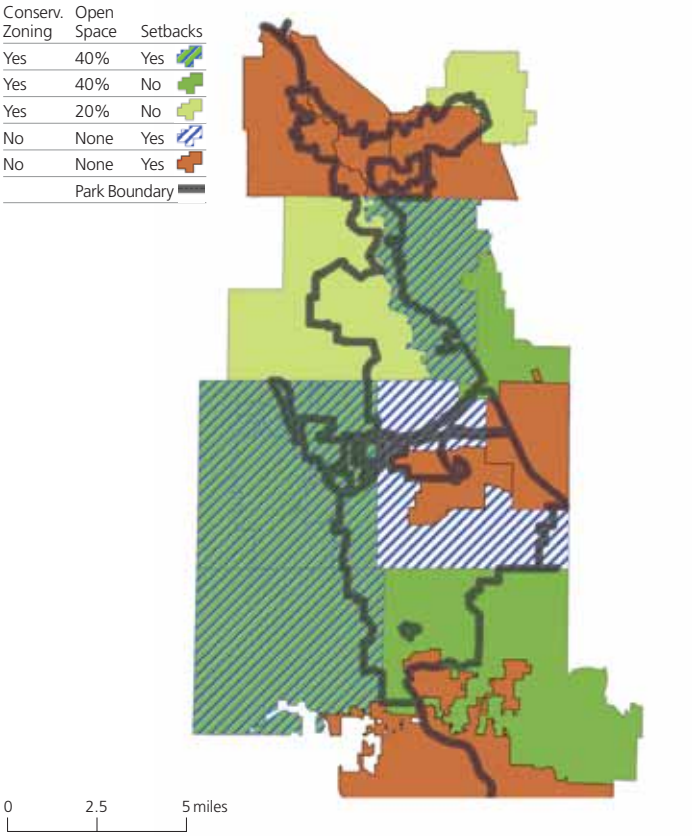
Flood damage from unusually heavy rainfall in July 2003 leaves the railroad tracks of the Cuyahoga Valley Scenic Railroad crossing the open air. However, through increasing development in surrounding communities and the subsequent decrease in land available to absorb runoff, even moderate stormwater can now cause flooding in and around Cuyahoga Valley National Park.

As watershed imperviousness increases, damage to park infrastructure also increases.

IMPERVIOUSNESS: SUBBASINS




LOCAL ZONING AND ORDINANCES




To identify high-priority areas to target through public planning, staff at Cuyahoga Valley National Park assessed (left) imperviousness at the subbasin scale and (right) local zoning and setback ordinances in the national park. Healthy subbasins (in green, left map) that extend beyond the park are priorities for protection, especially those in communities lacking conservation zoning and setback ordinances (in brown, right map).

assess watershed imperviousness and review local zoning and setback ordinances.

Scientific literature has established a set of thresholds indicating that watersheds are relatively healthy until they surpass 10% imperviousness. After that point there is a steady decline in quality. (Watersheds at or above 25% imperviousness are considered to be in poor condition.)

Using GIS-based tools and analysis, the team found that 14 of 27 watersheds (52%), most largely contained within the park, remain in good condition (less than 10% imperviousness). However, these watersheds typically extend beyond the park boundary and thus face development pressures. Analysis revealed that even within impacted and poor-quality watersheds, many subbasins (37%) remain healthy. Healthy watersheds and subbasins were considered critical areas for protection.

The review of local zoning regulations and ordinances revealed that only 8 of the 15 communities (53%) have some type of conservation development zoning regulation in their code. Only 6 of the 15 communities (40%) have riparian setback ordinances. Some communities that lack conservation zoning or setback ordinances are located in healthy watersheds. These communities were identified as priorities for outreach.

This team effort has resulted in increased local community and media interest. Park presentations to local planning and zoning commissions, stormwater management officials, and community organizations have effected positive change on several projects. The park is now increasingly asked to comment on development proposals and to participate in community planning.

Information is also now being shared with several local communities that are revising their zoning codes. Community-specific reports that encourage zoning updates and maps that depict possible changes in imperviousness from various development scenarios are being generated. Such buildout scenarios are facilitating effective communication of the importance of watershed stewardship.

All in all, these efforts demonstrate that by integrating science-based watershed assessments with an understanding of local zoning, national parks facing similar external development pressures may better protect downstream park resources by influencing change beyond their boundaries. ■

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# Midwestern national parks use best available science to "mimic" natural conditions in bison and elk management

*By Daniel S. Licht and Joshua J. Millspaugh*

**A LARGE, AGITATED BISON** is prodded down a narrow chute by National Park Service (NPS) employees at Badlands National Park. At the end of the line, gates drop in front of and behind the animal, pinching it tightly. Resource managers then decide the animal's fate: release it back into the park or remove it from the herd.

Two hundred years earlier at the same site, a pack of wolves looked down upon another herd, assessing each animal for weakness. The old and the young were especially vulnerable. The predators made a decision and an animal was killed, shaping the demographics of the herd.

Wolves are now absent from Badlands, Wind Cave, and Theodore Roosevelt National Parks. However, these three parks in South and North Dakota support fenced-in bison herds; the latter two are also home to elk. To meet carrying capacity objectives, such as preserving floral diversity, park staffs periodically cull surplus bison and elk. Until recently this management practice was done with little consideration of natural herd demographics.

National Park Service policies direct managers to conserve not only native species but also natural patterns and processes, such as maintaining natural age and sex structures among ungulate herds. When large predators are absent from an ecosystem and cannot be restored for ecological, political, or logistical reasons, management must intervene, ideally in a way that mimics nature. Such activities require a thorough understanding of natural conditions.

To gain this understanding these parks and the Midwest Regional Office partnered with Dr. Josh Millspaugh of the University of Missouri to reconstruct natural bison and elk demographics. A regional block grant of $16,926 from the Natural Resource Preservation Program funded the study through the Great Plains Cooperative Ecosystem Studies Unit (CESU). Millspaugh and his graduate-level class conducted the research. The collaboration was an excellent example of how the CESU can obtain exceptional information for park managers at reduced cost and give students at partner universities a real-world problem to solve.

The class used an interdisciplinary approach to reconstruct herd demographics in the presence of (1) only predators, (2) Native Americans before arrival of the horse, and (3) Native Americans during the horse-dominated period. Students reviewed historical literature for insight into ungulate and predator demographics and also examined anthropological information for evidence of human densities, caloric needs, and harvest patterns. Data from the Vore buffalo jump, a sinkhole in Wyoming where Native Americans stampeded bison, were especially useful in reconstructing the sex and age structure of harvested bison. The students applied soils information and GIS technology to estimate historical forage availability in the parks and the likely ungulate densities that could be supported. They also used predator-prey data and theory to estimate the likely take of various age and sex classes. Because wolves

Bison graze peacefully in Badlands National Park where they are periodically culled to meet range objectives. Animals removed from the park are live-transported to help start herds elsewhere, for example on Native American reservations. Park managers are using scientific information from a recent study to develop management plans that would help them mimic natural patterns of age and sex ratios of bison and elk herds at three Great Plains parks where wolves are absent.

Elk herds at Wind Cave and Theodore Roosevelt National Parks may have an unnaturally high proportion of mature bulls, according to a recent study. A high proportion of breeding-age male elk can reduce the size of harems, potentially leading to increased strife. Conservation of natural herd demographics is one of many factors considered when selecting animals for removal.

are absent from the Great Plains, the researchers relied on information from other ecosystems, such as Yellowstone National Park, demonstrating how wolf restoration there has implications beyond that park. Finally, they compiled existing demographic information from the three parks to develop a user-friendly computer model.

Final study results, delivered in 2005, were timely because the parks are in various stages of developing bison and elk management plans. The computer model is particularly useful, allowing the parks to evaluate and compare various culling scenarios (e.g., yearly versus periodic). Of course the management plans will need to reconcile NPS policies of naturalness with herd genetics and disease concerns, vegetation objectives, and fiscal, logistical, and political realities.

Managing wildlife in a way that mimics natural conditions and processes is an important goal of resource stewardship of national parks. This study of bison and elk demographics at Badlands, Wind Cave, and Theodore Roosevelt National Parks gives managers good information to consider for culling actions. ■

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# The Ozark hellbender: An indicator of unseen change at Ozark National Scenic Riverways

*By Jessica Luraas*

**OZARK NATIONAL SCENIC RIVERWAYS**, located in southern Missouri, supports one of the most pristine rivers in the country, the Current River. It also supports a very unusual species, the Ozark hellbender (*Cryptobranchus alleganiensis bishopi*). The hellbender is a large, strictly aquatic salamander that can reach a length of 2 feet (61 cm) and live for 30 years. It has very specific habitat requirements, including cool, spring-fed waters with high oxygen levels and large, flat rocks for refuge. Known populations of the Ozark hellbender are found in only four watersheds in the hills of southern Missouri and northern Arkansas. To the casual observer who sees the clear waters of the Current River, the Ozark hellbender appears to have ideal habitat and water quality for a healthy population. Unfortunately, this is not the case. The species has rapidly declined throughout its range, 77% over the last 20 years. This decline has prompted its listing as a candidate endangered species under the Endangered Species Act. In 2005, with funding from the Natural Resource Challenge, the Heartland Network—part of the national Inventory and Monitoring Program—contracted Dr. Chris Phillips, a herpetologist with the Illinois Natural History Survey, to conduct a parkwide inventory of hellbenders, map all suitable habitat, and develop a long-term monitoring protocol.

## At the current rate of decline, Ozark hellbenders could disappear in the next 20 years in parts of their range.

Along with the rapid population decline over the last 20 years, previous population inventories in Missouri and Arkansas have found few juvenile hellbenders, indicating a lack of consistent reproduction that may be caused by increased levels of pesticides, nutrients, and endocrine disrupters that affect fertility and hatching. In recent years, tumors, lesions, missing or deformed limbs, and other abnormalities have become more common. Exact causes for population decline are unknown and more research is needed to definitively determine them, but hellbender experts suggest the causes may relate to changes in the Current River watershed (outside park boundaries). These include increased sediment and nutrient-loaded runoff, removal of large flat rocks from streambeds, gravel mining, and other stream channel alterations. Other causes could be the presence of nonnative trout that prey upon juvenile hellbenders, illegal collection for pet trade, and indiscriminate killing by anglers. At the current rate of decline, Ozark hellbenders could disappear in the next 20 years in parts of their range.

Phillips surveyed more than 70 miles (113 km) of river in summer 2005 and found only five hellbenders at four locations. For perspective on the drastic reduction of population density, in the 1970s researchers located 300 to 500 hellbenders per kilometer (0.6 mi) of streambed in the North Fork of the White River, a watershed adjacent to the Current River. The inventory and a complete map of all suitable habitat within the park will be completed in summer 2006. Data will be used to

develop a statistically robust sampling design and long-term monitoring protocol. The protocol will be shared with other agencies monitoring Ozark hellbender populations so that similar methodologies can be applied throughout the hellbender's range, allowing for more integrated and comparable data among watersheds over time.

Efforts to save the remaining Ozark hellbenders are dependent on first understanding the population status and developing statistically sound monitoring protocols to track changes over time. The National Park Service is playing an active role as part of the Hellbender Working Group, an interagency effort to develop a recovery plan in conjunction with state agencies in Missouri and Arkansas, the US Fish and Wildlife Service, several area universities, and the St. Louis Zoo. The park holds high hopes that the combination of monitoring information and efforts of this conservation partnership will lead to effective protection of this sensitive species. ■

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A healthy Ozark hellbender has a life span of up to 30 years and does not reproduce until five to seven years of age. Those factors, combined with the hellbender's specific habitat demands, make this species a key indicator of broader changes in water quality, habitat, and land use in the surrounding area.

Hellbenders require cool, spring-fed waters like the Current River in the Missouri Ozarks.

# Research to identify sources of nitrogen pollution at Rocky Mountain National Park

*By Elizabeth Waddell and Terry Terrell*

**MORE THAN 20 YEARS OF RESEARCH** on air and water quality in Rocky Mountain National Park by scientists with the US Geological Survey, University of Colorado, Colorado State University, and other scientists has identified nitrogen deposition as a growing threat to park resources. A comprehensive new study begun in 2005 integrates chemistry, physics, meteorology, and mathematical modeling to determine the sources and fates of nitrogenous emissions affecting the park. Air samples are collected in a variety of sampling devices spread out over a geographically extensive area and then analyzed for a chemical "fingerprint" that uniquely identifies the sources of various types of nitrogen pollution. Once managers know the sources of the pollution most affecting the park, this information can be shared with regulatory agencies and the public to help craft a strategy to manage this growing problem. The study is the result of a unique cooperative effort of the Colorado Department of Public Health and the Environment, NPS Air Resources Division, and Rocky Mountain National Park.

Nitrogen-bearing emissions such as oxides of nitrogen ($NO_x$) and ammonia ($NH_3$) play key roles in the formation of ozone, in contributions to visibility degradation, and in atmospheric deposition of reactive chemicals that are altering the natural ecosystems of Rocky Mountain National Park. Effects include changes in aquatic plant species composition (diatoms), surface water nitrogen saturation, and changes to soil and tree chemistry. Results of models projecting current annual increases in nitrogen deposition into the future suggest not only a continued decline in air quality and ecosystem function but also episodic fish kills within 20 years unless the increasing rate of nitrogen deposition is controlled.

*Effects [of nitrogen deposition] include changes in aquatic plant species composition …, surface water nitrogen saturation, and changes to soil and tree chemistry.*

The first step to reducing deposition is to determine specifically where the $NO_x$ and $NH_3$ emissions originate. Agriculture is the largest source of ammonia, which comes from both fertilizer use and animal waste. Motor vehicles, fossil fuel–fired power plants, and oil and gas production are all major sources of $NO_x$. But what is not known is whether the impacts measured in the park are due to pollution from the urban communities just east of the park or from sources throughout Colorado, or if a significant amount of the pollution entering the park is transported long distances from places like California or the Midwest.

Whose $NO_x$ falls on Rocky Mountain National Park? Park managers hope to begin to answer that question in 2006 when initial results from the study become available. ■

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In contrast to the west side of Rocky Mountain National Park, Engelmann spruce forests east of the Continental Divide exhibit higher nitrogen content and chemical imbalances in both soils and trees. Park managers are concerned about nitrogen deposition at the park because of various ecological effects associated with it. For example, research in forests in other parts of the country has shown that excess nitrogen may make trees less resistant to insect infestation, cold, and drought.

Researchers at Rocky Mountain National Park are deploying a variety of sophisticated air quality monitoring equipment to accurately measure different types of air pollution reaching the park. These "mini-vols" will determine the geographic distribution of that air pollution.

# Precipitation and fire effects on flowering of a threatened prairie orchid

*By Gary D. Willson, F. Adnan Akyuz, and Manda J. Page*

**PIPESTONE NATIONAL MONUMENT**, a small cultural park in southwestern Minnesota, includes areas of remnant tallgrass prairie that are habitat for a small population of the threatened western prairie fringed orchid (*Platanthera praeclara* Sheviak & Bowles), a perennial plant with a lifespan of less than 10 years. Managers at the park conduct prescribed burns in the tallgrass prairie in spring to control smooth brome (*Bromus inermis* Leyss.) and other invasive cool-season grasses. In the early 1990s, managers became concerned that the prescribed burns might have a negative effect on prairie forbs, including the threatened orchid. In response they initiated a monitoring program in 1995 to track the status of the orchid population over time. Monitoring included an annual census of flowering plants in mid-July. Scientists with the USGS Biological Resources Discipline and the Prairie Cluster Long-term Monitoring Program (now part of the Heartland Inventory and Monitoring Network) then used these data in a study undertaken to provide management recommendations for the use of prescribed fire in orchid habitat that would help conserve the orchid population. Results of the study were accepted in December 2005 for publication in spring 2006.

The monitoring record over 10 years revealed that the number of orchid plants that flowered varied considerably, ranging from 0 to 221. The prairie was burned in 1997 and 2002 and the number of orchids that flowered in those two years also fluctuated dramatically: 3 and 124 plants, respectively. Flowering, it seemed, must respond to factors

The flowering of the western prairie fringed orchid (above) can be impacted by prescribed burning (left), depending on precipitation before and after burning. The plant produces buds in August for flowering the following July. Results of a recent study will help managers at Pipestone National Monument in Minnesota to plan prescribed burns in a manner that is sensitive to the conservation of this threatened plant species.

# Study finds introduced black locust tree harbors nonnative understory at Cape Cod

*By Betsy Von Holle*

**A THREE-YEAR STUDY** at Cape Cod National Seashore (Massachusetts) has found that some invasive species, in this case black locust (*Robinia pseudoacacia*), appear to support the presence of other nonnative species. Black locust, a nitrogen-fixing tree native to the central Appalachian and Ozark Mountains, is considered to be one of the top 100 worldwide woody plant invaders. It reproduces aggressively in areas with full sun, well-drained soil, and little competition. Black locust spreads by root suckering and stump sprouting to form groves of trees interconnected by a common fibrous root system. This study was initiated to determine the impact of introduced black locust on an upland coastal ecosystem and to estimate the spread of this species at Cape Cod National Seashore.

Betsy Von Holle conducted the research as part of the postdoctoral National Park Ecological Research Fellow program, coordinated by the National Park Service, National Park Foundation, and Ecological Society of America and funded by the Andrew W. Mellon Foundation. Additional support came from the National Science Foundation and the National Park Service. Von Holle is sponsored by the Harvard Forest, a long-term ecological research site that is part of Harvard University.

In field research conducted in summer 2003 through 2005, Von Holle and her students in the Harvard Forest Summer Program studied the introduced nitrogen-fixing black locust tree and its understory. They found that black locust had an average of 10 times the number of nonnative species under its canopy as did native species, primarily pitch pine

other than burning. Previous research on this orchid suggested that precipitation in combination with burning is the primary cause of variation in numbers of flowering plants. Fortunately, Pipestone has a National Weather Service Reporting Station that has kept records since 1950 and thus offered a tremendous opportunity to further investigate precipitation and fire effects on flowering.

Using the orchid monitoring data and precipitation history, the researchers compared the counts of flowering plants from the nonburn years with precipitation totals during six growth stages of the orchid. They found that about 77% of the annual variation in the number of flowering plants was explained by precipitation in two

*Managers became concerned that the prescribed burns might have a negative effect on prairie forbs, including the threatened [western prairie fringed] orchid.*

stages of the orchid's annual life cycle before flowering: during bud development in the previous August, and during dormancy in the previous winter (October through March). Results suggested that above-normal precipitation in August stimulates plants to develop buds capable of flowering the next summer, whereas above-normal precipitation in the previous dormant season saturates the soil, stressing or killing plants and reducing flowering.

The investigators applied a model developed from nonburn years to precipitation records from the two burn years that occurred during the study and compared them with the counts of flowering plants from those years. Results were inconsistent between years but suggested that lack of precipitation following a burn could reduce flowering depending on the amount of the precipitation deficit. Therefore, the resulting recommendations for protecting the orchids when prescribed burning is planned are based on precipitation history and forecast.

For example, if the previous late summer was wet and the winter dry (high number of flowers predicted), the spring precipitation forecast is the deciding factor when considering burning. Fire in a dry spring in such a year would further dry the soil, possibly causing flower buds to abort. But when a wet spring is forecast in such a year, burning would do no harm if it occurred in early to mid-May, before the plants were large enough to be damaged by the fire. It might even be beneficial by reducing competition from exotic cool-season plants.

If, however, the previous late summer was dry and the winter wet (low number of flowers predicted), the coming summer's flowering would be minimal, and burning in either a dry or wet spring would not impact flowering. Nonetheless, burning in early to mid-May, before the orchids are fully emerged, is recommended so that foliage of nonflowering plants is not damaged.

Finally, to minimize any unforeseen negative effects of fire on the orchid population, the researchers strongly recommend that only a portion of the habitat be burned in any year. A safe option would be to divide the orchid habitat and burn only half or less. In the future, when managers at Pipestone National Monument must make decisions about burning in this remnant tallgrass prairie, they will know that they need to consider not just the current weather but also that of the past and future. ■

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(*Pinus rigida*), white oak (*Quercus alba*), and black oak (*Quercus velutina*). They also found that nitrogen levels are significantly higher under locust than under native forest approximately 66 feet (20 m) away from the locust stand.

Total land cover of black locust in the outer Cape has significantly declined over the past three decades, as revealed by historical aerial photographs. Stands that were formerly locust are currently intermediate between native pine-oak and nonnative locust stands in levels of ammonium and nitrate, and also intermediate in nonnative species richness. Preliminary results from a greenhouse study conducted in spring 2005 indicate that the nonnative understory plant species Kentucky bluegrass (*Poa pratensis*) and bouncing bet (*Saponaria officinalis*) had significantly greater growth in soils collected from under black locust and former

*Understanding that native forests are associated with lower levels of nonnative plants means that … letting the process of natural succession continue [from invasive black locust] to native pitch pine and oak is the best control.*

locust stands than in soils collected from native pine and oak forests or sand, which served as a control. Thus the introduction of a novel functional type (nitrogen-fixing tree) into this sandy, nutrient-poor, upland forested ecosystem resulted in "islands of invasion" within this otherwise invasion-resistant system.

These research findings are relevant to park management when prioritizing activities to control invasive plants. Understanding that native forests are associated with lower levels of nonnative plants means that, where black locust occurs in areas that are reforesting, letting the process of natural succession continue to native pitch pine and oak is the best control.

Chief of Natural Resources at Cape Cod National Seashore Nancy Finley found this information very useful. She says, "This study saved the park from initiating efforts not only to control black locust stands … but also to control the heavily invasive-infested understory within those locust stands.… In time, both the locust and its exotic community will decline without any park intervention … allowing us to focus on more imminent problem sites." Given the mosaic landscape of Cape Cod and many other national parks, understanding the susceptibility of habitat types to invasion of exotic plants is a necessary tool to manage the landscape for the highest native biodiversity. ■

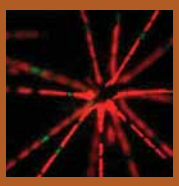
**Betsy Von Holle**
National Parks Ecological Research Fellow

BLACK LOCUST LAND COVER, SALT POND, CAPE COD NATIONAL SEASHORE


Investigators in the black locust study analyzed aerial photography of Cape Cod National Seashore (Salt Pond area shown here), identifying a significant decline in the extent of the invasive tree species from 1970 to 2002. Though they encourage growth of nonnative plants, nitrogen-fixing black locusts eventually give way to native pine and oaks and understory native plants.

# 3 National Parks as Laboratories and Frontiers for Knowledge

Our national parks are tremendously important not only for their recreational values but also as natural laboratories. As exquisite expressions of biological,



physical, historical, and prehistoric diversity, they hold great potential for untold fascinating and meaningful discoveries about our world and our role in its stewardship. Their status as protected, lesser-disturbed, and stably administered sites suits them particularly well for inquiry, and their value as frontiers for knowledge only increases as unprotected areas become ever more fragmented. The articles in this chapter expand on these themes, in particular detailing progress in documenting park biological diversity. Through productive partnerships that use both traditional and state-of-the-art inventory techniques, scientists are discovering new life-forms and recording new species for parks, information that both is useful for park management and adds significantly to our understanding of the world. One technique, genetic sequencing, is being used with great success to analyze an astonishing array of life-forms from Yellowstone Lake. Some of these activities are valuable also for their involvement of the public as citizen scientists in documenting life and learning about parks through hands-on science. Other activities reported herein highlight the value of parks as places to study resource disturbance and recovery and to refine research methods. The following articles illustrate a few of the superior opportunities national parks afford as laboratories of nature.

*"As change throughout the world accelerates, as park data bases are developed, and field research facilities expanded, the value of parks for science appreciates beyond measure."* — **National Research Council**

# Molecular approach to biodiversity inventory doubles list of known species in Yellowstone Lake

*By John D. Varley*

**BIOLOGICAL DIVERSITY IN YELLOWSTONE LAKE** is much richer and broader than scientists have previously concluded. Collecting community DNA and separating 16S and 18S genes for sequencing, researchers participating in a pilot Molecular All Taxa Biodiversity Inventory (MATBI) have identified more than 251 new species for the lake since 2004, nearly double the amount known previously. Just two of the species inventoried in the MATBI were known from earlier species lists, and the new discoveries belong to all three domains of life. More species will be identified in the future as longer-term analytical techniques are completed.

Despite 135 years of near-heroic efforts to classify life in Yellowstone Lake, scientists using All Taxa Biodiversity Inventory (ATBI) techniques had documented just 263 species and had generally concluded that the lake is a "simple ecosystem." Thus the chance to compare the existing taxonomic list of species and genera from ATBIs with a cutting-edge genomics survey of species was an irresistible opportunity to improve scientific knowledge of this unusual, high-elevation lake.

*One species … has never been observed outside its Antarctic habitat, and another has never been found outside its unusual home in an oxygen-deficient basin in the Caribbean Sea.*

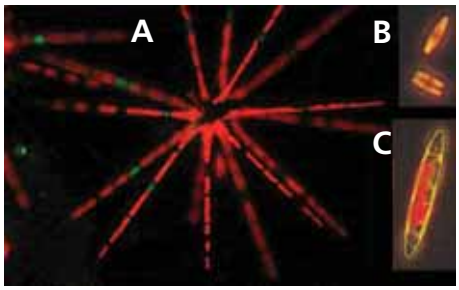
The MATBI was initiated in 2004 as a proof-of-concept trial to evaluate its potential for determining the eukaryotic, bacterial, and archaeal biodiversity within Yellowstone Lake. The National Park Service (NPS), the Gordon and Betty Moore Foundation, Diversa Corporation, Eastern Oceanics, Inc., the US Geological Survey, and the Yellowstone Park Foundation funded and collaborated on the project. In this pilot study, researchers used standard methods to sample "normal" cold-water subalpine aquatic habitats and submerged geothermal sites from boats, by scuba divers, and by remotely operated vehicles. However, the ability to separate a mixture of community DNA into coherent parts that can be sequenced and analyzed is what sets this inventory technique apart from other molecular analysis work.

Domain Archeabacteria was populated for the lake for the first time, with 103 species, including several clusters that appear to be new to science. Identified separately was the newly discovered group Nanoarchaea, which increased the worldwide number of species from a single named species to about 28 unnamed lineages. The new species reported here are the first freshwater records of the group. In domain Eubacteria, the lake's known species jumped by 71 new additions, and in domain Eukarya, the number of known species increased by 28 forms.

Qualitatively, the newly identified species were a curious lot, ranging from the common to the unbelievable. In domain Eukarya, for example, researchers expected species typical of the lake's subalpine and nutrient-poor character, and indeed one species assemblage was indicative of that type and similar to species in the Laurentian Great Lakes, Siberia's Lake Baikal, and several high-elevation lakes in the Andes Mountains. But they also found marine organisms, species known only from rivers and streams, and still others that are indicator species for nutrient-rich or polluted waters. Until now, one species found has never been observed outside its Antarctic habitat, and another has never been found outside its unusual home in an oxygen-deficient basin in the Caribbean Sea.

Inventorying a park's biodiversity is a bigger job than many people realize. First, most of the easily identified species have already been named, leaving the hard ones still to be done. One park biodiversity expert believes that 99% of the park's microbes and 75% of its invertebrates remain undiscovered. Second, using centuries-old techniques like Linnaean taxonomy—as valuable as it is—simply takes too much time and expertise to make inventory completion feasible. Newer techniques are sorely needed. Knowing what each park has in terms of its biodiversity got a big boost in 1998, when Congress reinforced the importance of species inventories as part of the NPS mission. The inventory program has been supported with "new money" from the Natural Resource Challenge initiative, and progress has been made in a portion of the parks, including Yellowstone. But managers are still far from knowing even 50% of the total species in any park.

NPS fisheries biologist Phillip Doepke and Eastern Oceanic's Dave Lovalvo prepare to deploy the remotely operated vehicle (ROV) from the research vessel *Cutthroat* on Yellowstone Lake. The ROV was fitted with a bucket sampler for the Molecular All Taxa Biodiversity Inventory and used to scoop life-rich soil samples from a geothermal feature on the floor of Yellowstone Lake.




Diatoms are among the many life-forms discovered in the MATBI of Yellowstone Lake. Cultured in a laboratory in San Diego, California, *Asterionella formosa* is shown in A. The red fluorescence corresponds to chloroplasts, the green to the nuclei when excited with blue light. Two additional diatoms (B and C) have no affinity to known diatoms in the GenBank database.

The study participants believe the pilot MATBI on Yellowstone Lake can now be considered a new biodiversity assessment model, melding classic Linnaean taxonomy with genomics inventories. The model has the potential and practical capacity to increase biodiversity identifications from a presumed 1% to more than 50% of the total extant. Additionally, inferred physiology of the new species based on their evolutionary history and specific known genes will increase the possibility of identifying previously unknown energy pathways in the lake ecosystem. It will also now be possible to combine findings obtained during the long history of research on the lake with new information to foster new and better ecological interpretations. At the least, the MATBI model will better assist managers in their efforts to conserve biodiversity, the vast majority of which consists of the small organisms that remain the largest void in the story of life on Earth. ■

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# Exploring the micro-wilderness of Boston Harbor Islands

*By Bruce Jacobson*

**ISLANDS, LIKE THE GREAT WESTERN WILDERNESS,** capture the imagination with their vast complexity. Yet islands are finite; they have a human scale and seem more *knowable* than other places. Thus the idea of inventorying island life may be daunting, but certainly not impossible.

In 2005 Dr. Edward O. Wilson, ecologist and world-renowned philosopher, conservationist, and ant expert, with his Harvard entomologist colleague, Dr. Brian Farrell, began an unprecedented exploration of what Wilson calls "the little things that run the world" at Boston Harbor Islands, a national park area in Massachusetts. Although biological inventories are not new, it is unusual to fully explore "the little things." Most animal inventories focus on mammals, birds, reptiles, amphibians, and fishes. Instead the Boston Harbor Islands effort documents the inhabitants of the islands' micro-wilderness, providing an opportunity to focus on animals that can be examined firsthand, literally in hand. Many of the animals living in the micro-wilderness on the Harbor Islands are so small that, depending on the species, tens, hundreds, or even thousands would fit in the palm of your hand.

One exciting aspect of the five-year Harbor Islands invertebrate project is that it is not limited to a small cadre of scientists. The proximity of the islands to the largest urban population in New England offers the opportunity for many people to explore firsthand, using the park as a natural laboratory. Students, citizen scientists, and amateur naturalists, guided in the field by taxonomic experts, can join in the search for life among the nooks and crannies of the islands.

*Many of the animals living in the micro-wilderness on the Harbor Islands are so small that, depending on the species, tens, hundreds, or even thousands would fit in the palm of your hand.*

The presence of each species identified is documented in the field through notes, global positioning coordinates, and photography. A comprehensive database will be made available to the public on the Internet, containing all of the field information and images of specimens documented during each of the four planned field seasons. Eventually, scientists will also sequence a fragment of DNA for every invertebrate species collected that can be used for rapid identification as part of a growing international effort to provide such DNA bar codes, as they are known, for all species on Earth.

Research and curatorial aspects of the project are under the direction of Dr. Farrell, professor of biology and curator in entomology at the Museum of Comparative Zoology, Harvard University. Museum collections and literature will be used to identify most specimens, but taxonomists from around the world may be called on to identify any unusual finds. Jessica Rykken filled a postdoctorate position in July with responsibility to further develop the biodiversity inventory.

The 34 islands comprising Boston Harbor Islands national park area (left) vary in size, degree of development, and distance from Boston. They offer both a recreational haven for urban residents and a laboratory in which to learn about natural change and stewardship of the island ecosystem.

In June 2005, Harvard biologist E.O. Wilson (below) and students from Odyssey High School kicked off a five-year project to explore the invertebrates of Boston Harbor Islands. Through intensive, short-term "bio-blitzes," the many project partners hope to gain a strong understanding of the islands' biodiversity, possibly discovering new species and even testing the theory of island biogeography.

Bruce Jacobson, superintendent of Boston Harbor Islands, oversees public outreach efforts about the project. Management of this unique park is coordinated among representatives from the National Park Service, US Coast Guard, Massachusetts Department of Conservation and Recreation, Massachusetts Water Resources Authority, Massachusetts Port Authority, City of Boston Office of Environmental Services, Boston Redevelopment Authority, Thompson Island Outward Bound Education Center, The Trustees of Reservations, Island Alliance, and Boston Harbor Islands Advisory Council.

Partnership liaison Mary Raczko facilitates programs to involve citizens and students in cooperation with Kelly Fellner, supervisory park ranger. The Boston Harbor Islands staff develops traveling museum exhibits, schedules curriculum-based school trips to the islands, coordinates public "bio-blitzes," and facilitates development and distribution of publications and posters. Research learning centers, one at Acadia National Park and another at Cape Cod National Seashore, promote the use of data throughout the academic community for research purposes, exploring ecological questions related to island biogeography, climate change effects, and other possible societal impacts on biodiversity.

Restoring the natural diversity of the islands is a long-term goal of the Boston Harbor Islands Partnership. It will take the focused attention of a generation of scientists and resource managers to accomplish this major endeavor. A key component in the restoration effort is the identification and understanding of all organisms, from the smallest microscopic creatures whose importance is largely unknown to larger organisms whose role in the ecosystem is better understood. Few comparable opportunities exist to explore the interrelationship among all these creatures, large and small. As more details of those relationships come to light, new methods of native species conservation and restoration may also be revealed. ■

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# Tomales Bay Biodiversity Inventory: A successful partnership in action

*By Ben Becker and Joe Kinyon*

**THE COAST OF CALIFORNIA IS PRIZED** not only for its scenic beauty but also for the abundance of marine mammals and other living things found there. Along the coast, visitors may see whales, sea lions, and birds as well as bobcats and elk. However, there are many plants and animals that are harder to spot. In fact the presence of hundreds of coastal inhabitants was completely unknown until recently. In its third year the Tomales Bay Biodiversity Inventory (TBBI) made considerable progress in the basic but essential task of describing the biodiversity of Tomales Bay, a coastal estuary located on the central California coast approximately 40 miles (64 km) northwest of San Francisco. As of October 2005, the inventory had recorded 2,008 species, a 24% increase from the 1,623 species documented just two years earlier.

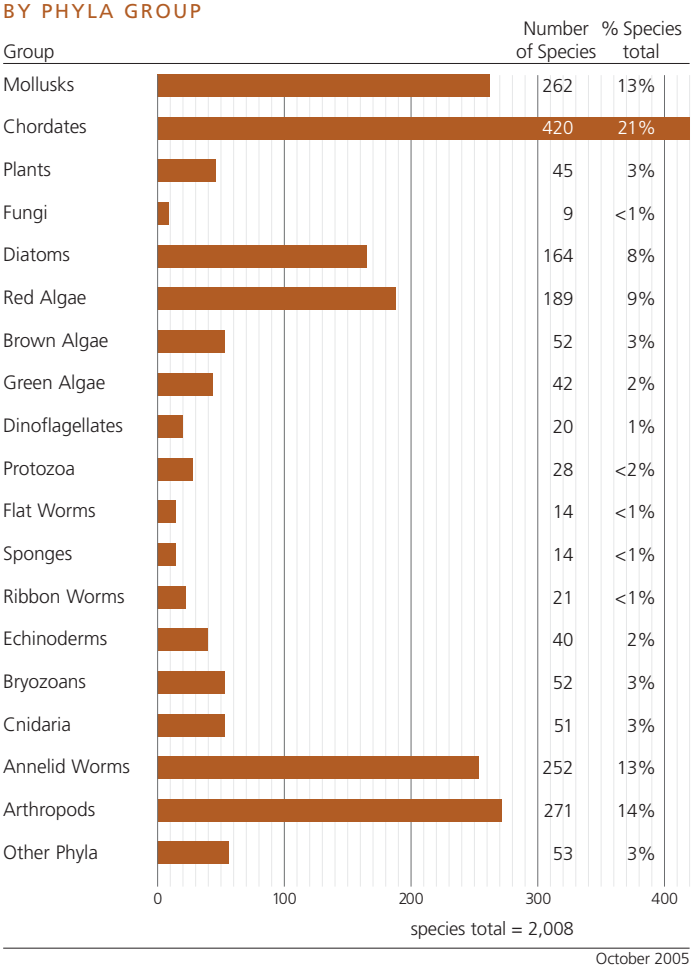
Partnership is a big part of the success of this effort. The TBBI is supported by the Tomales Bay Biodiversity Partnership, an organization of community members and scientists dedicated to fostering a deeper understanding of the life of Tomales Bay. Cooperation for research and management of the bay, which abuts land owned or managed by various public and private entities, has been established among more than 40 organizations and individuals, including Point Reyes National Seashore, Golden Gate National Recreation Area, the California Department of Parks and Recreation, and the Marin County Parks and Open Space District. At the watershed level, the Tomales Bay Watershed Council is a collaborative group of organizations and businesses working to protect and restore the waters and lands of the watershed. The Pacific Coast Science and Learning Center, located at Point Reyes National Seashore, supports the inventory by hosting a full-time GIS specialist, a position made possible by a generous grant from the Marin Community Foundation.

*As of October 2005, the inventory had recorded 2,008 species, a 24% increase from the 1,623 species documented just two years earlier.*

In this context the TBBI coordinates its efforts with partners to combine targeted research and data management activities intended to help inform and guide management efforts. Data management coincides with new data collection and experiments that grow out of ongoing inventories and taxonomic work for fish, marine invertebrates, and algae. Several new research programs are designed to directly inform management. These efforts include research on native oyster population ecology, the impacts of invasive snails on biodiversity, and the effects of algal blooms on native eelgrass, a foundational species that provides forage for many fishes, invertebrates, and waterbirds in the bay.

Tomales Bay, California, is the site of an ongoing biodiversity inventory that includes participation of the Pacific Coast Science and Learning Center at Point Reyes National Seashore, the Golden Gate National Recreation Area, and many

DIVERSITY OF SPECIES IN TOMALES BAY, CALIFORNIA, BY PHYLA GROUP




October 2005

other partner organizations. This view of the bay shows Walker Creek marsh (foreground), Hog Island (left), and the national seashore (background).

The data collection and experimentation have important on-the-ground applications for land managers and local partners. For example, the inventory database is facilitating the identification of species of local interest and their habitats that may require special management or protection. The inventory effort is also providing new information about invasive species and range extensions that frequently occur in marine systems during unusually warm years. For example, during the warmer-than-average summer of 2005, California grunion (*Leuresthes tenuis*), a southern California fish that spawns on sandy beaches during extremely high tides, made its first documented appearance in the bay. This range extension resulted in a new species for the database as well as excitement among anglers and scientists alike.

Further information on the TBBI and the Tomales Bay Watershed Council is available at www.tomalesbaylife.org and www.tomalesbaywatershed.org. The TBBI Web site has a searchable bibliography with more than 500 entries on the ecology and species of the bay. Species lists are available by taxonomic hierarchy to allow users to quickly determine if a particular species occurs in the bay or to examine how biodiversity differs among groups. In the future the TBBI will continue to contribute to documenting and protecting the biodiversity of this special California bay. ■

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# Smokies' search for life robust in eighth year

*By Becky Nichols*

**THE ALL TAXA BIODIVERSITY INVENTORY** (ATBI) celebrated its eighth successful year in 2005 and continued to advance its goal of discovering all of the species that occur in the 815-square-mile (2,111 sq km) Great Smoky Mountains National Park, which straddles Tennessee and North Carolina. Yet again, the field season was a flurry of activity. The participating ATBI scientists have now documented 3,572 new records for the park and 565 species that are new to science. This brings the total number of new biodiversity discoveries made at Great Smoky Mountains National Park to more than 4,000 since the ATBI began in 1998.

Participating scientists used creative strategies for finding and documenting species. For example, the Coleoptera Taxonomic Working Group (TWIG) conducted a "mega beetle blitz" for two weeks in June. The blitz was an intensive field sampling effort conducted by experts that resulted in several new records for the park. Additionally, four posters by the Coleoptera TWIG, showing beetle blitz results and other ATBI activities in the Smokies, were presented at the Entomological Society of America's annual conference. The total number of beetle species for the park is now 1,804.

*ATBI scientists have now documented 3,572 new records for the park and 565 species that are new to science.*

A lepidoptera "bio-quest" was held in May, earlier than previous sampling efforts, in hopes of finding those species of butterflies and moths that emerge early in the year. Nearly 400 species were recorded, several of which were new records for the park and one that was also a new family record. An additional effort during this event was the collection of DNA samples from selected specimens. First, one leg from each butterfly or moth species was collected and frozen in liquid nitrogen for "DNA bar coding." The bar coding process is based on the quick assessment of the mitochondrial DNA in the specimen. Comparisons can then be made of this DNA information with other closely related species; these comparisons assist with final species determination and phylogenies. Finally, the remainders of the moths and butterflies selected for DNA analysis were sent to the cryogenic storage facility at the American Museum of Natural History in New York to archive tissues of these species in a repository for future generations.

One measure of the continued success of the ATBI is that scientists remain enthusiastic about the project and continue to seek funding for research within the park. For example, in 2005 two National Science Foundation grants were awarded to conduct ATBI research. Also, the mini-grant program awarded $52,000 to support ATBI

The All Taxa Biodiversity Inventory celebrated its eighth successful year in 2005 and continued to advance its goal of discovering all species that occur in Great Smoky Mountains National Park. A "fern foray" was part of the flurry of activities that took place in the 2005 field season. These periodic efforts to determine the distribution of fern species in the park rely heavily on volunteers. The volunteers pictured are taking a GPS reading before beginning the fern foray in August at Clingmans Dome.

Great Smoky Mountains National Park hosted a lepidoptera "bio-quest" in May 2005. The sampling effort was conducted sooner in the year than in previous seasons in hopes of finding those species of butterflies and moths that emerge early in the year. Nearly 400 species were recorded, including the Pandorus sphinx moth (*Eumorpha pandorus*) pictured at top.

educational projects, including teacher workshops and community outreach. These funds also sustained research projects covering a wide range of taxonomic groups, including fungi, tardigrades, slime molds, flies, beetles, thrips, water mites, and algae. Some of this funding was also used to conduct blitz-type collecting activities.

The ATBI has uncovered and will continue to uncover the amazing range of life in Great Smoky Mountains National Park. As the inventory matures, it also provides important lessons for how parks can encourage scientists to conduct research in national parks and advance technology that improves human understanding of the natural world. ■

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# Slime mold inventory: Studying one group of species across the National Park System

*By Paul Super*

**AN ALTERNATIVE APPROACH** to the "all species–one park" model now applied to natural resource inventories in national parks is to conduct a comprehensive inventory of a single taxonomic group of species across representative sites of the entire National Park System. The National Science Foundation (NSF) has provided an opportunity to pilot this alternative approach, and the taxon chosen to be surveyed in the first round of the NSF Planetary Biodiversity Inventory Grants is eumycetozoans (you-my-SEE-tuh-zo-ans), a group of organisms saddled with the unfortunate common name of "slime molds."

This inventory approach is an efficient way of addressing certain groups of species of great concern and involving smaller park units that cannot support a lot of researchers at one time. Our system of national park units represents a nearly comprehensive sample of the major habitat types in North America. A survey of representative park sites throughout the country could provide an in-depth understanding of the distribution of the majority of organisms on the continent. The laboratory of Drs. Steve Stephenson and Fred Spiegel at the University of Arkansas is heading up the grant. This lab has the capacity to identify the samples that such a broad-based survey would generate at no additional cost to the parks.

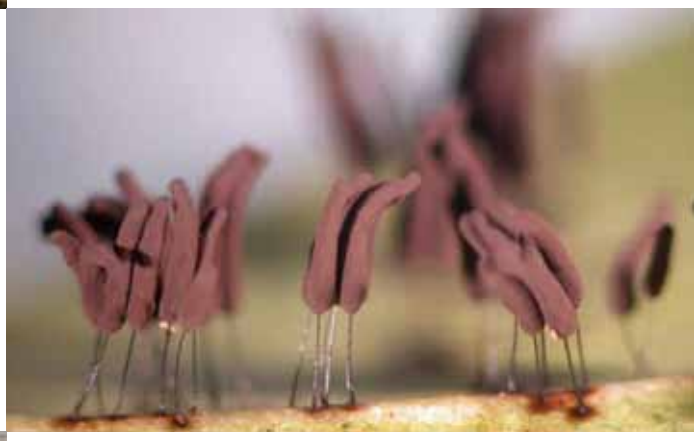
*A survey [for particular taxa in] representative park sites throughout the country could provide an in-depth understanding of the distribution of the majority of organisms on the continent.*

Eumycetozoans are easy to culture from soil and various types of dead plant material. Larger species can be located and identified by their fruiting bodies. Research to date indicates that the diversity of slime molds in a habitat may decline with such environmental threats as acid deposition, global climate change, and increased domination by exotic plants. Eumycetozoans may also be good indicators of the health of a soil ecosystem stressed by a toxic waste spill, incidental application of fertilizers or pesticides from neighboring private lands, or habitat isolation by development outside a park's borders. The first step in appreciating eumycetozoans is to know what we have in our national parks.

At the end of 2005, 23 park units, from Denali in Alaska to Everglades in Florida, were participating in this project and 11 research learning centers were assisting with its coordination. The inventory is conducted by different methods at different sites to determine what model works best. In Great Smoky Mountains National Park (North Carolina and Tennessee), most of the collecting was done by professional taxonomists. At Tallgrass Prairie National Preserve (Kansas), after National Park Service staff provided orientation, volunteers collected material and sent it to the University of Arkansas laboratory for culturing. At Wind Cave National Park (South Dakota), park staff collected samples while in the field for other purposes without a significant addition to their workload.

Theresa Yednock of Congaree National Park, South Carolina, examines a specimen of the slime mold *Arcyria cinerea* during the June 2005 training held at Great Smoky Mountains National Park. Twenty-three national park units are participating in an alternative biodiversity inventory that involves multiple parks surveying one taxonomic group.

*Metatrichia vesparium* (above) is one of the more common myxomycetes, one of three groups of slide molds, to be encountered in early autumn. It typically fruits on the dead bark of decaying logs.



The fruiting bodies of *Stemonitis herbatica* typically occur on living plants, a common substrate for most myxomycetes. Certain groups of slime molds could serve as biological indicators. For example, some species that occur on the bark of living trees are absent in areas of high pollution, leaving the bark surface almost devoid of slime mold.

The distinctive netlike fruiting bodies of *Hemitrichia serpula* (left) can be found on decaying wood and bark in late summer.

In June 2005, partners from 14 park areas attended a "Train the Trainers" workshop funded by the US Environmental Protection Agency at Great Smoky Mountains National Park to give them the expertise to oversee inventory work at their own parks. One such trainee, elementary school teacher Melissa Forsythe of Big Bend National Park (Texas), leads her students to collect samples—an outstanding educational experience with a real-world application. Images of fruiting bodies cultured by the students can be uploaded to a data server where Stephenson and his team can either make the identifications or tag them for additional examination.

The National Park Service is charged with preserving outstanding examples of America's natural, cultural, and recreational resources for the enjoyment, education, and inspiration of future generations. Yet we are only just beginning to understand the complex natural systems in our care in ways that will help us successfully manage them for the future. The Natural Resource Challenge initiative has helped to document the types, abundance, and distribution of species in national parks by funding a comprehensive inventory of vertebrates and vascular plants. To understand other life-forms, Great Smoky Mountains National Park and Point Reyes National Seashore have embarked on comprehensive inventories of all species within all or part of their park boundaries, not just the vertebrates and vascular plants. Other parks are also in the process of establishing their own all-taxa inventories.

The eumycetozoan survey is yet another method of adding to our knowledge of life on Earth and in our national parks, and is scheduled to run through 2007. By then, in addition to understanding the diversity and biogeography of eumycetozoans, project coordinators expect to know what it would take in terms of funding, staff, volunteer training, and methodologies to conduct similar multipark inventories of native bees, land snails, and other taxa that provide significant ecological services to the national parks and to the world as a whole. ■

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# River of research in Olympic National Park

*By Jerry Freilich*

Two dams along the Elwha River will be dismantled beginning in 2008, giving researchers a rare opportunity to study the trajectory of river restoration at Olympic National Park. The Elwha Research Consortium helps coordinate research and develops educational materials about the efforts of the many scientists, community members, and students involved in these projects.

**THE ELWHA RIVER RESEARCH CONSORTIUM** took a big step forward in early 2005 when the National Science Foundation awarded two grants, totaling $1 million, to consortium partners. The funds will provide support for two projects and enable the consortium to become a recognized entity that facilitates, coordinates, and promotes research and education efforts along the Elwha River in Olympic National Park, Washington.

*Because all of the land above the upper dam is within the national park, the opportunities for research in an otherwise pristine ecosystem will be unique.*

The timing is right for such a venture because two hydropower dams on the Elwha River in Olympic National Park are scheduled for removal beginning in 2008. This effort will be the largest dam removal ever attempted and one of the largest river restoration projects of all time. This congressionally approved $184 million project will permit five species of salmon to return to waters they have been locked out of for more than 90 years. Because all of the land above the upper dam is within the national park, the opportunities for research in an otherwise pristine ecosystem will be unique. Unfortunately, removing the dams and protecting drinking water for the nearby city of Port Angeles will use nearly all the appropriated funds, so the budget contains little for education or research.

Enter the Elwha consortium. The two grants received in 2005 will assist the consortium in coordination of research efforts that enable Olympic National Park to be used as a living laboratory. Some of the questions to be explored are how long it will take for natural spawning populations to reestablish themselves in a pristine river that has been blocked for almost a century, and how hatchery fish will interact with wild fish coming up the river. Other important questions concern the transport of sediments out of the river and their effects on both domestic drinking water and the fishery. Perhaps the most important question the Elwha consortium may help answer is the relative importance of marine-derived nutrients to forest ecosystems. Using isotopic signatures to determine the origin of biomass, researchers can determine the quantitative and qualitative differences between rivers without salmon and rivers that have salmon. As time runs out before demolition of the Elwha dams begins, the Elwha Research Consortium is an example of the synergy possible in a group of like-minded and determined scientific partners to capitalize on the unique opportunity presented in Olympic National Park. ■

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# An ecological monitoring parable: System-level changes following the loss of island foxes at Channel Islands National Park

*By Cathy Schwemm, Charles Drost, and John Orrock*

**BIOLOGISTS AT CHANNEL ISLANDS NATIONAL PARK**, California, are learning that the absence of the endemic island fox (*Urocyon littoralis*) from San Miguel and Santa Rosa Islands also affected other species and ecological processes, resulting in a unique natural experiment of the effects of removing a top predator from an ecological system. Because Channel Islands National Park had a broad-based natural resources monitoring system in place, park staff and partners were able to document dramatic changes in populations of other species that occurred during the fox decline, yielding surprising insights into island ecosystems. This knowledge is important not only to the National Park Service for future protection and management of the foxes, but also to the larger scientific community, as it might relate to ecological questions regarding the role of predators in structuring ecosystems.

The ecological lessons learned, particularly on San Miguel Island, may be more evident and distinct because of the simplicity of this system. Only two mammals are native on San Miguel: the island fox and an endemic subspecies of deer mouse (*Peromyscus maniculatus streatori*). Historically, foxes were the dominant predator of the mice, and mice one of the foxes' most important food sources. Data from the park's vertebrate monitoring program, ongoing since 1993, showed a sudden and dramatic increase in mouse densities beginning in 1998, the year the fox population on that island was effectively extirpated. These results strongly suggest that foxes were a regulating factor of mouse populations, and their absence consequently allowed mice to increase to higher levels. The data also revealed that mouse populations decreased in the absence of foxes to numbers lower than previously recorded, likely because of a population crash driven by density-dependent regulation within the mouse population.

The loss of foxes has also had indirect effects on elements of the island ecosystem. Before 1998, counts of barn owls (*Tyto alba*) along a 6-mile (9 km) transect never exceeded 10 individuals, while recent counts have been as high as 28. Barn owls are specialist predators of small rodents, and likely responded to the increases in mouse numbers. Short-eared owls (*Asio flammeus*) and northern harriers (*Circus cyaneus*) were rare to uncommon winter visitors before 2000. Both species have since established resident populations, and in 2002, US Geological Survey biologists documented the first known successful nesting of harriers on the island. The eggs and chicks of these ground-nesting species historically would have been prey for foxes but survive when foxes are absent.

Finally, researchers collaborating with the National Center for Ecological Analysis and Synthesis and the University of California–Santa Barbara are investigating whether mouse behavior has changed on the island in response to reduced predation risk. Prey species are known to change foraging habits based on their

The extirpation of island foxes from San Miguel Island, one of five islands within Channel Islands National Park, resulted in ecosystem-level changes. The simplicity of the island system may have helped facilitate observation of these changes, though without monitoring, the perturbations may not have been detected.

# Mammal inventory surprises managers at Vicksburg National Military Park

*By Jennifer M. Linehan, Michael Mengak, and Kurt A. Foote*

**VISITORS ENTERING THE ILLINOIS MONUMENT**, a neoclassical edifice built in 1906 in commemoration of the Illinois soldiers who served under General Ulysses S. Grant during the Civil War Siege of Vicksburg, are usually unaware that they are entering a bat cave as well. The domed structure is open at the top and features sculpted crevices within which big brown bats (*Eptesicus fuscus*) have made their home for years. These bats seem inured to the regular disturbance of human voices echoing around the chamber and return to the monument each morning following their nightly foraging flights.

Until FY 2005, staff at the park was unsure which species of bat inhabited the memorial. This data gap has been filled thanks to the efforts of a University of Georgia (UGA) graduate student working on a formal and comprehensive mammal inventory for the park. The University of Georgia is a partner institution within the Gulf Coast Cooperative Ecosystem Studies Unit. This study completes Vicksburg's vertebrate fauna inventories coordinated by the Gulf Coast Inventory and Monitoring Network using Natural Resource Challenge funding. It also completes the last of the park's 12 basic natural resource inventories prescribed by the Challenge initiative, giving managers information about the type, distribution, and abundance of a variety of natural resources at this "cultural" park. Among the findings are two new bat species records for Warren County: the hoary bat (*Lasiurus cinereus*) and the Seminole bat (*Lasiurus seminolus*), both foliage-roosting species.

In addition to identifying new species and the nocturnal inhabitants of the Illinois Monument, the mammal inventory has yielded other pertinent information regarding bats. A radiotelemetric study was implemented to investigate the roosting structures of evening bats (*Nycticeius humeralis*) in the national military park. Though the sample size of this study is small, preliminary results have shown that the majority of roosting structures used by radio-tagged evening bats were located in utility poles. This is of interest to park managers because it may suggest that tree roosts are limiting for this species, and that evening bats are adapting to an increasingly developed landscape. This example highlights the ideal situation of this urban park, which commemorates Civil War history, as a laboratory for studying the effects of habitat alteration upon wildlife. ■

The mammal inventory at Vicksburg National Military Park identified two new species of bats for Warren County, including the hoary bat. A pregnant female is pictured here.

The Illinois Monument and other artificial structures are important roost sites for bats at the national military park.

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perception of risk, potentially increasing or decreasing impacts on food sources. Specifically, this research concerns whether higher mouse numbers and altered foraging patterns stemming from fox extirpation are having negative impacts on native island plants.

Two important lessons were learned from monitoring critical natural resources at Channel Islands National Park, even in the absence of identified threats. Most important, monitoring data revealed the sharp decline in fox populations. Without these data, one and possibly two subspecies of fox almost certainly would have gone extinct. Moreover, because monitoring programs were also in place for vegetation, land birds, and other resources, data from these programs were collected fairly easily and are now available to help interpret the impacts of the loss of foxes and make informed decisions regarding long-term fox conservation. Given the speed and severity of the fox decline, the ecosystem-level effects following loss of the foxes probably would have gone undetected without this monitoring.

The loss of the island fox from these insular systems was clearly undesired and, one hopes, temporary, but did provide an opportunity to observe ecosystem changes resulting from a large perturbation. National parks can be unique natural laboratories; however, the level of success of both planned and unplanned ecological experiments lies largely in the ability of parks to have natural resource monitoring and research programs in place prior to potential impacts. In future years, biologists and partners at Channel Islands National Park hope to glean more understanding of the ecology of the fox and the larger island ecosystems as more data are collected and wild populations of foxes are restored. ■

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# The significance of dating Sierra Nevada caves

*By Greg Stock*

**RESULTS PUBLISHED IN 2005** from ongoing cave research in Sequoia and Kings Canyon National Parks shed light on the landscape evolution of the Sierra Nevada. This study also refines a method for reliably dating cave development. When dated, caves indicate rates of river incision, or downcutting, the primary erosional process governing the pace at which landscapes evolve. Although river incision could be due to climate change (i.e., increased precipitation increases the size of a river and its erosional power), results of this study suggest that tectonic uplift is the driver in the Sierra Nevada. As rivers cut deeper into their canyons, solution caves—which form at the water table or river level—are left perched in the steep canyon walls, far above modern rivers. Hence, caves increase with age from valley floor to rim and record the history of river downcutting in the southern Sierra Nevada. Yet determining rates of landscape evolution in this region first requires establishing the ages of caves that have recorded landscape changes over time.

*This rapid erosion may relate to a globally recognized shift in climate …, but these new data strengthen the case for tectonically driven uplift.*

As with any cave analogy, however, what on the surface seems simple may become complicated at depth. That is, caves are difficult to date because by definition a cave is a void, and how does one date empty space? Geologists usually determine the age of a cave by the materials deposited in it (e.g., sediments, bones, and speleothems), but dating is constrained by the oldest deposits, which may be far younger than the cave itself. To tackle this problem, Greg Stock, a researcher from the University of California–Santa Cruz, collected sand and gravel samples from 14 caves from the Sierra Nevada and dated them using cosmogenic burial dating. Cosmic rays striking Earth's surface create rare isotopes such as aluminum-26 and beryllium-10. So long as rocks stay on the surface, these isotopes are produced in them. The longer the rocks are exposed at the surface, the more cosmic rays accumulate in them. When these rocks become deeply buried, however, such as when sand and gravel wash into a cave, they are shielded from cosmic rays and the isotopes cease to accumulate. Instead they begin to decay radioactively at a rate determined by their half-life, which scientists can measure. The half-life of aluminum-26 (0.73 million years) is roughly half that of beryllium-10 (1.6 million years), so the ratio $^{26}Al/^{10}Be$ decreases exponentially with time as sand and gravel remain within the cave.

Cosmogenic burial ages from caves in Sequoia and Kings Canyon National Parks reveal a pulse of river incision 1–3 million years ago. This rapid erosion may relate to a globally recognized shift in climate around this time, but these new data strengthen the case for tectonically driven uplift. As the mountains rose, the river gradients steepened and the rivers cut down more quickly to reach a new equilibrium state. The dated caves suggest that the Sierra Nevada topography is a product of two uplift events, the first nearly 100 million years ago and the second much more recently, in the past 3–10 million years. ■

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In a cave perched high above a valley floor in Kings Canyon National Park, researcher Greg Stock collected sand and gravel, which he analyzed using a recently developed method called cosmogenic burial dating. Sediments buried in this cave indicate an age of 2.4 million years. Cave age provides evidence for the timing and rate of uplift of the Sierra Nevada.

# 4 Battling Nonnative Species and Diseases

A major challenge in protecting natural resources in the national parks is the battle against nonnative species and diseases. Invasions of nonnative plants, fungi, animals, and other organisms threaten the integrity of park ecosystems by

displacing native species, destroying natural habitat, disrupting natural ecological processes, and changing biological diversity in park terrestrial, aquatic, and marine ecosystems. These are very difficult problems with solutions that are often cost-prohibitive and require long-term commitment. Effective management applications include surveillance to anticipate and detect nonnative species invasions and the incidence of disease, application of control treatments, and restoration of damaged resources to a natural condition. Research is also important in revealing the degree of impacts to park resources and in developing intervention techniques. Moreover, both education that raises awareness of the problem and enforcement of regulations are crucial to prevent the unwanted spread of nonnative species. Where processes that degrade resources cannot be controlled, management treatments that reduce other stresses on embattled resources may be helpful. Most of the articles in this chapter expand on these themes; however, two are outside the strict discussion of nonnative species impacts. They are included because they reflect potential impacts of humans on the environment and raise related concerns for the protection of native park species. As the articles indicate, nonnative species and diseases wield a profound influence on the ability of the national parks to preserve park resources and pose very serious implications for the future of these special places.

*"Even when alien species can be removed, a community of species that has been changed by evolution remains. Return of native species to an original evolutionary state is impossible, and a 'ghost of alien influence' will remain."* — **George W. Cox**

# Cattail sleuths use forensic science to better understand spread of an invasive species

*By Joy Marburger, Steve Travis, and Steve Windels*

**ALL CATTAILS ARE NOT CREATED EQUAL.** Mounting evidence suggests that a European invader is hybridizing with native cattails in three national parks in the Great Lakes region. This is posing a threat to native biodiversity and causing a "hybrid swarm" into areas where cattails (*Typha* spp.) have never been seen. The invasive narrowleaf cattail (*T. angustifolia*), which has been spreading inland from the eastern seaboard since the early 1800s, has the ability to hybridize with the native broadleaf cattail (*T. latifolia*). In doing so, it has given rise to a new species of cattail (*T.* x *glauca*), first described in the 1960s. This hybrid has the ability to disrupt many ecosystem services traditionally associated with freshwater wetlands. This may be related to its ability to tolerate both of the habitats occupied by its parents (and then some).

All of this comes as no surprise to many taxonomists who have noticed the difficulty in using botanical keys to identify cattail species. However, it did raise questions, including: Why is the variation so extreme? Since most hybrids are sterile, are hybrid cattails fertile? And just how widespread is this phenomenon in our national parks? To find out, biologists with the National Park Service and the US Geological Survey (USGS) began a joint research project. The goal of the two-year study was to uncover the role of hybridization in the spread of cattails in the three Great Lakes national parks. The USGS Park Oriented Biological Support Program and in-kind support from Indiana Dunes National Lakeshore, the Great Lakes Research and Education Center, and Voyageurs National Park (Minnesota) provided funding for the cooperative effort.

*This research sends a message that hybridization is an important piece of the puzzle in cattail invasiveness across the Great Lakes national parks.*

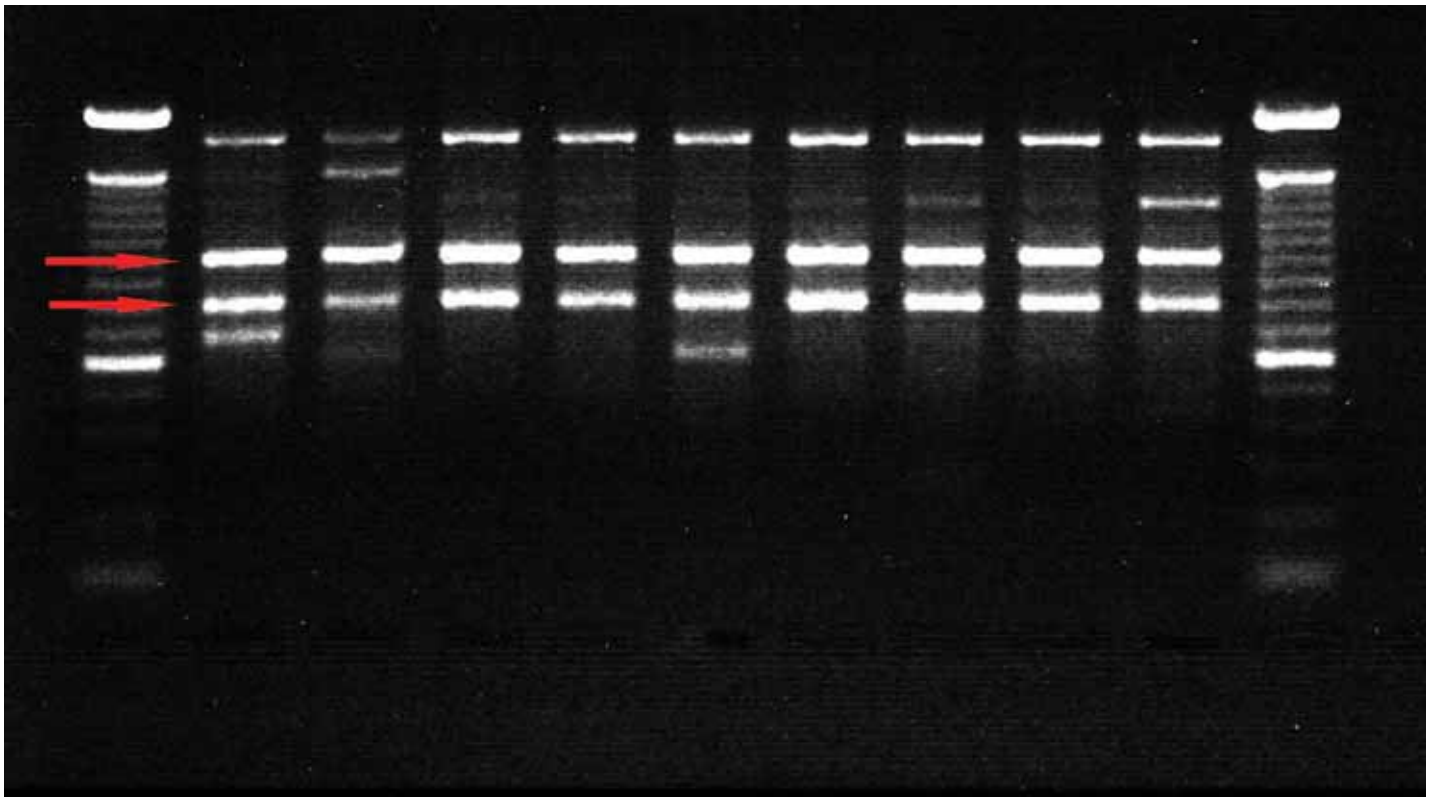
Joy Marburger (Great Lakes Research and Education Center) and Steve Windels (Voyageurs National Park) teamed up with Steve Travis of the USGS National Wetlands Research Center in Louisiana. At this research center, modern molecular techniques are being used to investigate the recent ancestry of invasive cattails and to correlate their hybrid status with their physical characteristics and overall aggressiveness. In 2004 the cattail sleuths collected leaf material from more than 700 plants from wetlands at Indiana Dunes, Voyageurs, and Saint Croix National Scenic Riverway (Minnesota and Wisconsin).

In 2005, results of this genetic analysis provided solid DNA evidence that most of the cattails in the three national park wetlands are, indeed, spontaneous fertile hybrids between *T. angustifolia* and *T. latifolia* or their offspring. The highly variable physical characteristics of the cattail's flowering spikes support this observation. Though a few narrowleaf cattails are still present in the parks, the overall situation

Results of genetic "sleuthing" have provided solid DNA evidence that most of the cattails "swarming" in three Great Lakes national parks are spontaneous fertile hybrids of the native broadleaf cattail (*T. latifolia*, left) and the invasive narrowleaf cattail (*T. angustifolia*, right). Showing up in areas where they have never been seen before, these hybrid cattails are posing a threat to native wetland biodiversity.

A continuous stand of cattail hybrids at Indiana Dunes.

Variability of female cattail inflorescences (spikes) at three national park units (left to right): Indiana Dunes, Voyageurs, and Saint Croix.



DNA analysis of nine cattail leaves from Kabetogama Lake at Voyageurs National Park confirms the hybrid genetic nature of invading cattails. Similar patterns were found in the other two parks. Note that each specimen in the "bar code" has horizontal bands corresponding to genetic material of both *T. latifolia* (the native species, denoted by red arrow at top) and *T. angustifolia* (an invasive European cattail, denoted by red arrow at bottom).

has apparently progressed to the level of what plant biologists commonly refer to as a "hybrid swarm" throughout much of the Great Lakes region. In the easternmost parks, Indiana Dunes and Saint Croix, plants exhibit a greater genetic resemblance to the exotic *T. angustifolia*. At Voyageurs, the most northerly and westerly of the parks studied, the majority of the cattails bear a greater genetic resemblance to the native *T. latifolia* than to their exotic ancestor. In addition the higher incidence of first-generation hybrids at Voyageurs indicates that hybridization is a slightly more recent phenomenon there than at the other two parks.

This research sends a message that hybridization is an important piece of the puzzle in cattail invasiveness across the Great Lakes national parks. Nutrient runoff from urban and agricultural lands, and flood control may also be contributing factors in the spread of hybrid cattails. More ecological testing will be needed to piece it all together. Ultimately, resource managers will gain a clearer understanding of what they must do to preserve the genetic integrity of the pure native cattail and to control the unwanted spread of hybrid cattails in an effort to maintain and enhance wetland biodiversity throughout the Great Lakes region. ■

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# Spotted owls face increasing threat in ancient redwoods from invading barred owls

*By Kristin Schmidt*

**RESULTS FROM A 2005 MONITORING PROGRAM** in Redwood National and State Parks ("the park") reaffirmed the probability that the ancient redwood forest is losing a key component: the northern spotted owl (*Strix occidentalis caurina*). Listed as a threatened species under the federal Endangered Species Act, the spotted owl earned a place in history as the driving force behind old-growth forest preservation in the West. Now it is facing an increasing threat to its own preservation: the more dominant and aggressive barred owl (*Strix varia*), winging in from the East.

The barred owl, native to the eastern United States, expanded its range into the West in the late 20th century. Subsequently, the number of barred owl sites and the area of barred owl occupancy have increased throughout much of the spotted owl's range. Closely related to the spotted owl, the barred owl now occupies much of the forested habitat in Washington and Oregon. However, it has been slower to invade habitat in California, with one exception: Redwood National and State Parks.

First reported in the northernmost portion of the park in 1982, barred owls were reported in Prairie Creek Redwoods State Park and in lower Redwood Creek in the national park by 1992. In 1993 a three-year inventory of all suitable spotted owl habitat in the park began. Results indicated 35 to 40 territories distributed throughout the park, with core "activity centers" occurring primarily in old-growth forest. Each year since 1993, barred owls have been detected throughout the park with increasing frequency. They now occupy much of the park's suitable spotted owl habitat, including former spotted owl nest trees and core areas around spotted owl activity centers.

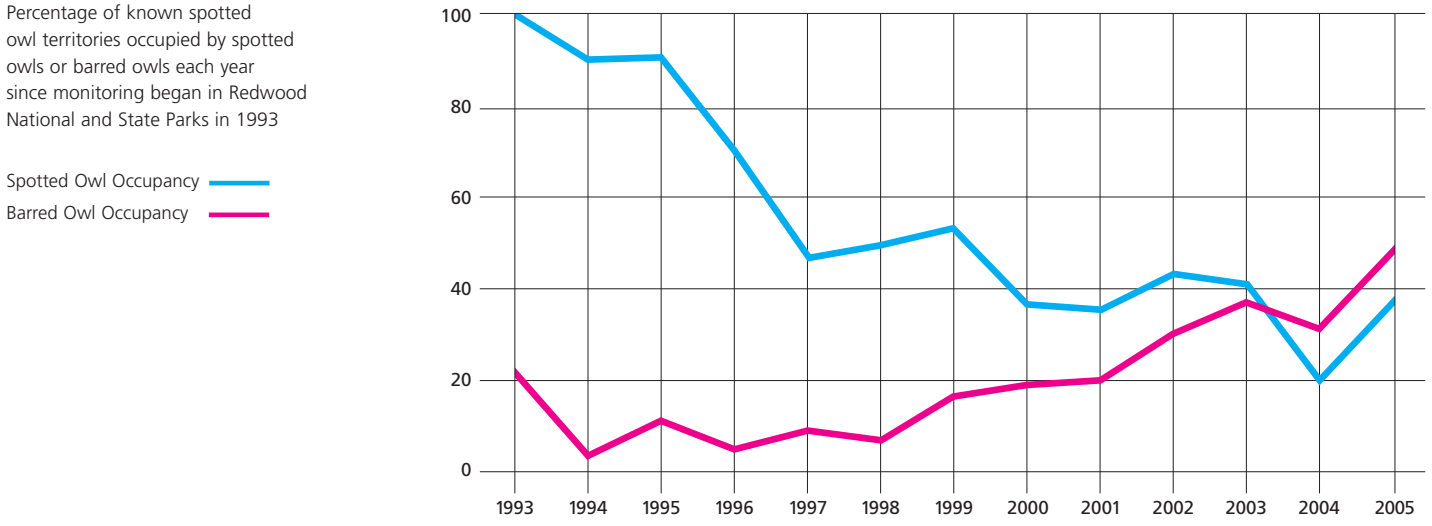
The barred owl, clearly the more dominant of the two owl species, is known to prey on spotted owls, and at least one such event has been documented in the park. Barred owls and spotted owls will hybridize, and anecdotal evidence suggests hybridization between the two species has occurred in the park. Hybridization has not become the significant problem that was predicted at the time the spotted owl was listed as threatened, but the barred owl does appear to affect spotted owl behavior. Each year surveyors find it more difficult to elicit spotted owl responses, the means by which they are located or "moused" to determine occupancy status (e.g., nesting or non-nesting). In 2005, spotted owls were detected at 9 out of 21 territories surveyed within the park, but occupancy status could be determined at only two of these sites. Some sites also contain barred owls, confounding efforts to determine whether spotted owls are present but not vocalizing, or whether they have entirely abandoned their territory.

*As of the end of the 2005 field season, an estimated 35 barred owl territories were identified in the park, a number equal to the original quantity of documented spotted owl territories.*

In addition to altering spotted owl behavior, barred owls may have a competitive edge. This is their ability to use home ranges that are a fraction of the 3,000 acres (1,215 ha) required, on average, by a spotted owl pair during breeding season. Other competitive

OCCUPANCY OF SPOTTED OWL TERRITORIES 1993–2005, REDWOOD NATIONAL AND STATE PARKS

Percentage of known spotted owl territories occupied by spotted owls or barred owls each year since monitoring began in Redwood National and State Parks in 1993



The spotted owl (above), a key component of ancient forests, is becoming increasingly rare each year in Redwood National and State Parks. The barred owl (right) appears with regularity in the park, occurring both at known spotted owl sites and at locations without a history of spotted owl activity. Biologists are concerned that barred owls are displacing spotted owls through their more aggressive and competitive behavior.

advantages may result from the barred owl's wider prey selection, more consistent reproduction, and larger clutch sizes. Each year, in the course of monitoring known spotted owl sites and inventorying suitable habitat, new barred owl sites are discovered. As of the end of the 2005 field season, an estimated 35 barred owl territories were identified in the park, a number equal to the original quantity of documented spotted owl territories. This estimate may be conservative, since barred owl data were collected incidental to spotted owl surveys. Little is known about barred owl territory size in coastal redwood forests. However, in recent years barred owls successfully produced more fledglings than did spotted owls in the park. In 2005, park staff documented a fledgling ratio of 4:1 for the two species.

Spotted owl inventory and monitoring will continue in the park with the goal of gaining deeper insight into the population status of the two species. Research is sorely needed to gain an understanding of barred owl habitat selection, diet, and home range size. The park is seeking to team up with other parks in the region in similar need of understanding the relationship between the owl species in order to preserve and protect the spotted owl. ■

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# Integrating natural and cultural resource management applications in the attack on nonnative plant species

*By Elaine F. Leslie*

**FOR CENTURIES, TRADITIONAL NAVAJO SUBSISTENCE** in Canyon de Chelly focused on grazing sheep, farming, and orchards. Today erosion, lack of water, invasion by exotic vegetation, and soil deterioration threaten these potent symbols of the Navajo Nation, with far-reaching consequences for the local economy and canyon families.

In 2005 an unprecedented assortment of partners convened to address a landscape-level invasion affecting the traditional way of life on the Navajo Reservation. The National Park Service, the Navajo Nation, the Natural Resources Conservation Service, the US Geological Survey, and Colorado State University have initiated two projects involving exotic vegetation removal to preserve the historical farming landscape and orchards of the canyon floor.

To implement the daunting task of removing miles of tamarisk (*Tamarix ramosissima*) and Russian olive (*Elaeagnus angustifolia*), intermixed with stunning landscapes of native cottonwoods, willows, and sheer canyon walls, the park made a decision to make this more than an exotic plant removal project. In an economically deprived area, job opportunities are few and far between. Therefore, the park set out to employ, train, and implement a local Navajo Conservation Crew, patterned after the highly successful Exotic Plant Management Team model, who could tackle the invasion for years to come. The team's connection to their Canyon de Chelly homeland has overcome the natural barriers created by dense stands of exotic species, as well as some perceived cultural barriers faced by reservation residents.

In 10 months the park's 26-member team has been trained and certified in herbicide and pesticide application techniques, exotic plant removal, and basic firefighting skills. They have treated and contained nearly 100 acres (41 ha) of tamarisk and Russian olive in research plots, canyon-bottom farmsteads, and orchards. Grandmothers and grandfathers, sons and daughters, and now even grandchildren are returning to tend their land and herd their sheep. Public meetings sponsored by the National Park Service now include discussions about native and heritage seeds and crops, farmers' markets, and the return of the traditional churro sheep.

Though initial funding came from the Recreational Fee Demonstration Program, efforts are under way to find additional funding to enable this team to continue the battle with exotic species within the national monument and to assist other park units and reservation lands in similar restoration efforts.

Side by side with local canyon community residents, the Canyon de Chelly team is restoring a vital watershed. In so doing they are restoring the memories, breezes, sunlight, and a traditional way of life to the canyon floor of the national monument. ■

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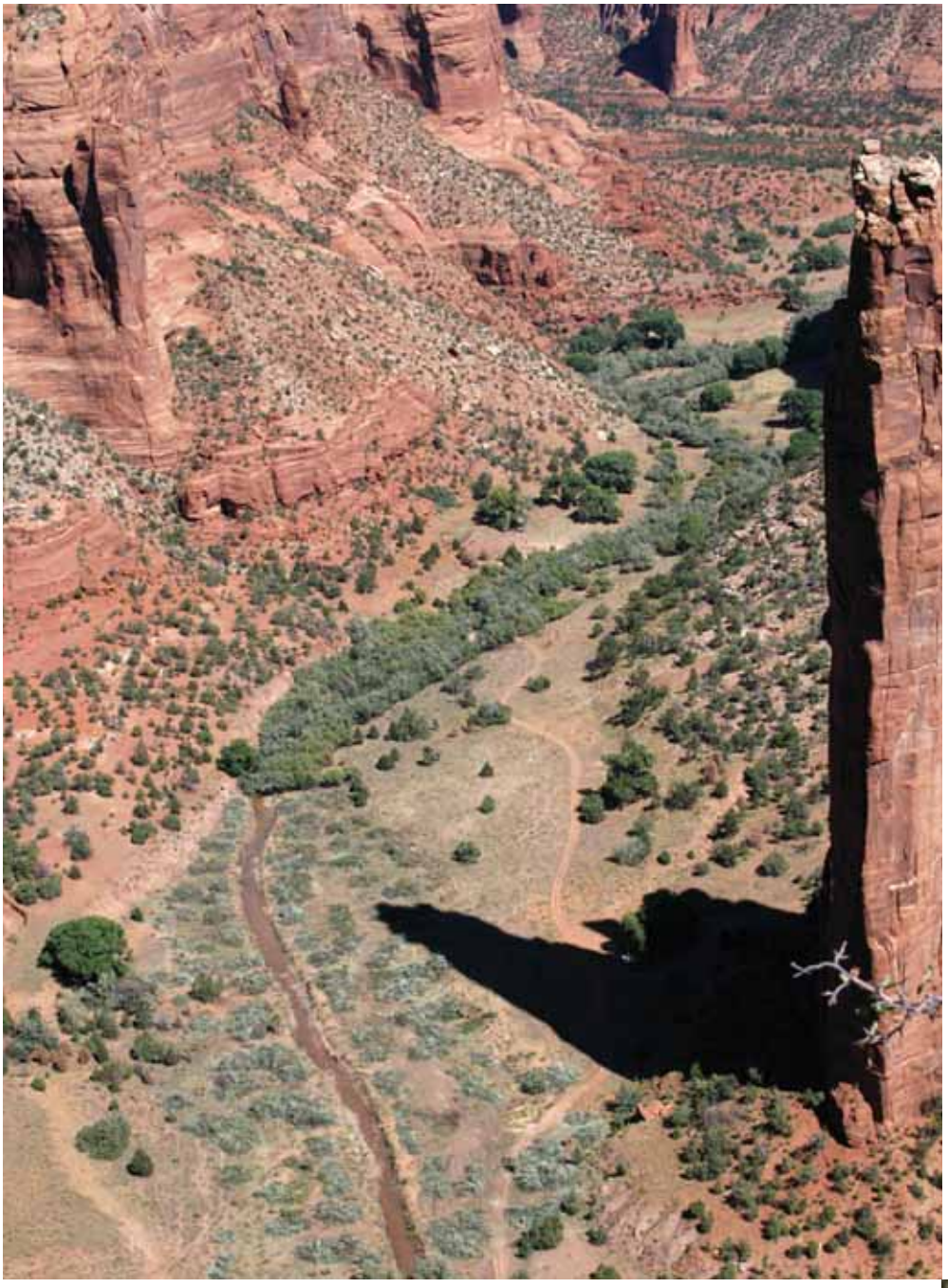

*The team's connection to their Canyon de Chelly homeland has overcome the natural barriers created by dense stands of exotic species, as well as some perceived cultural barriers faced by reservation residents.*

Nonnative tamarisk and Russian olive are cut and piled on the floor of Canyon de Chelly in the shadow of Spider Rock, an important cultural landmark on the Navajo Reservation and in the Four Corners area. These invasive tree species disrupt traditional lifeways of Navajo residents, alter natural conditions to the point of impairment in some areas, and threaten to replace native cottonwoods and willows. The national monument is at a critical threshold in addressing this issue.

In April 2005 the newly formed Navajo Conservation Crew, made up of 26 Navajo born and raised in the Canyon de Chelly area, began tackling the immense task of cutting nonnative trees and applying herbicide. Wood is distributed to Navajo residents of the canyon for burning and constructing fence posts. Slash is burned or chipped for mulch. Native cottonwoods and willows struggle to reestablish. Ten more years of control efforts like this are needed to bring the invasive species problem at the national monument to a maintenance level.

# Disease-resistant American elm to return to the National Mall

*By James L. Sherald*

**IN SPRING 2005 THE AMERICAN ELM** (*Ulmus americana*), once nearly wiped out by Dutch elm disease, was given a new chance to thrive in the nation's cities and forests. The National Capital Region's (NCR) Center for Urban Ecology, in cooperation with the USDA Agricultural Research Service's (ARS) Floral and Nursery Plant Research Unit, signed a nonfunded cooperative agreement and began propagating clones of the 'Jefferson' elm, a new Dutch elm disease–resistant American elm cultivar, for imminent release to the nursery industry. The parent tree was discovered among the original elms planted on the National Mall in the 1930s. It was recognized in the 1960s by Horace Wester, an NPS plant pathologist, for its unusual habit of developing leaves earlier in the spring and retaining them later in the fall than its 600 neighboring elms. After several years of subjecting nursery trees to controlled inoculations of the pathogen, first by the Center for Urban Ecology and later by the USDA ARS Floral and Nursery Plant Research Unit, 'Jefferson' has been found to be highly resistant to Dutch elm disease.

The National Mall and Memorial Parks in Washington, DC, manages one of the nation's premier stands of American elm. Though superb in form and tolerant to urban stress, the American elm is notorious for its susceptibility to Dutch elm disease. This devastating disease was first recognized in Washington, DC, in 1947 on the grounds of the Lincoln Memorial. Since then, Washington, like many other municipalities, has lost most of its elms. The National Mall and Memorial Parks, however, through an effective disease management and elm replacement program, continues to sustain a stand of 2,700 elms. Though the annual disease incidence has been low, usually between 1% and 2%, the loss of any elm is significant, particularly of specimen trees, mature and healthy examples of the species. Consequently managers have been very interested in finding resistant elms to reduce future losses and management expense.

Though many elm species, particularly those of European and Asiatic origin, are more resistant to Dutch elm disease than the American elm, they do not have the classic American elm form. Recently, however, several more disease-resistant American elm cultivars have been found. While these trees are not immune to the disease, they are highly resistant and, along with the 'Jefferson,' constitute an exciting prospect for the National Park Service to consider for the possible restoration of this species.

The 'Jefferson' elm is special to arborists in the nation's capital because it was identified among the original plantings on the Mall. The 'Jefferson' has a DNA profile typical of American elm. It can be propagated readily by vegetative cuttings, and over the last few years the National Park Service has grown and planted many 'Jefferson' clones throughout the region. Since 'Jefferson' may eventually become susceptible to a new strain of the pathogen that causes Dutch elm disease or some other disease or insect infestation, the National Park Service will never rely exclusively on 'Jefferson' or any single cultivar in its forest care. Instead, park managers will continue to diversify the population with new resistant selections as they become available. ■

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Resource managers collect softwood cuttings from 'Jefferson,' a Dutch elm disease–resistant tree on the National Mall, for propagation as clones. The USDA Agricultural Research Service's Floral and Nursery Plant Research Unit roots the cuttings in a mist-propagation bed at its field station in Glenn Dale, Maryland, where more than 100 'Jeffersons' will soon be released to interested nurseries.

This young 'Jefferson' elm was planted recently along Jefferson Drive on the National Mall near the parent tree.

# Sudden oak death moves east

*By Bruce Badzik*

**FIRST IDENTIFIED IN THE UNITED STATES** in the mid-1990s in coastal forests of California, sudden oak death has spread via infected nursery stock to seven nurseries in four East Coast states. The fungus-like organism, *Phytophora ramorum*, that causes the disease has killed more than 100,000 trees and infected numerous other plant species, such as rhododendron (*Rhododendron* spp.), wild rose (*Rosa gymnocarpa*), Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*), and coast redwood (*Sequoia sempervirens*). Investigators have documented the disease in trees at Muir Woods National Monument, Golden Gate National Recreation Area, and Point Reyes National Seashore in California. Though the disease has spread eastward, no forests in eastern national parks have been infected—yet.

*No forests in eastern national parks have been infected—yet.*

In 2005, researchers at the University of California–Berkeley produced a risk model of disease spread; results showed that the Appalachian Mountains area, home to Great Smoky Mountains National Park, is at high risk if exposed to the organism. Plant pathologists of the USDA Forest Service (USDA-FS) in Asheville, North Carolina, say the threat to forests in the Appalachian Mountains from this disease is "as large as it was from chestnut blight." Hence, a primary issue for NPS resource managers is proliferation of the disease.

In addition to forest plants, *Phytophora ramorum* can spread by the moving and handling of nursery plants. Moreover, hikers and bikers in California have transported the pathogen on the mud of their shoes and bike tires.

According to Susan Frankel, Sudden Oak Death Research Program manager with the USDA Forest Service, investigators sampled for the pathogen in 39 states in 2005, with data reported from twice as many forest locations as in 2004. Thus far, workers from 12 states have submitted 2,038 samples from 519 nursery perimeter locations and 472 forest locations. Researchers have analyzed 62% of the submitted samples and, as of October 2005, all have tested negative for *P. ramorum*. Though the deadly fungus was not detected, sampling continued through November 2005.

In addition, Steve Tjosvold, University of California Cooperative Extension researcher, and Steve Oak and Kurt Gottschalk, USDA Forest Service, initiated a project in 2005 that examines the susceptibility of selected eastern forest and woodland species to the disease. The USDA-FS Pacific Southwest Research Station funded the project. To detect early warning signs of the disease, the National Park Service is seeking additional funding through the NPS Recreational Fee Demonstration Program to conduct further surveys for sudden oak death in national parks throughout the country. ■

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Sudden oak death has spread from the coastal forests of California to the East Coast via infected nursery stock. Thus far, trees in eastern national parks, such as these red oaks in a mixed forest in Great Smoky Mountains National Park, have not been infected. More information about the disease is available at http://www.suddenoakdeath.org.

# Tracking the white pine blister rust epidemic in our national parks

*By Brent Frakes, Diana F. Tomback, and David Pillmore*

**LAND MANAGEMENT AGENCIES** in North America reached an important milestone in 2005 for addressing the white pine blister rust (*Cronartium ribicola*) epidemic. The National Park Service, working in cooperation with the Whitebark Pine Ecosystem Foundation (WPEF), developed a database for tracking blister rust infection in whitebark pine communities throughout the western United States and Canada. Researchers and managers from the USDA Forest Service (USDA-FS), Parks Canada, National Park Service, Bureau of Land Management, University of Montana, and University of Colorado at Denver and Health Sciences Center comprise the WPEF board. The database serves as a standard repository complete with data analysis tools and reporting options. It has the capability of exporting data to the USDA-FS Forest Health Protection Program, which tracks basic plot information geographically on whitebark pine (*Pinus albicaulis*) and limber pine (*Pinus flexilis*) from numerous surveys and studies, including those from the Forest Inventory and Analysis Program.

The NPS-developed database interfaces with the field protocol that the Whitebark Pine Ecosystem Foundation conceived and field tested. This protocol provides an international standard for measuring blister rust infection. It is efficient in delivering critical information, such as blister rust infection levels and tree damage. Within permanently marked belt transects of whitebark pine communities, investigators tag all assessed trees for future monitoring. By monitoring whitebark pine communities, managers will be able to prioritize areas for restoration, which involves harvesting seeds from potentially blister rust–resistant trees and planting seedlings for reestablishment. Managers of other five-needled white pine communities can modify and use both the protocol and the database for tracking blister rust in those communities.

*[The field] protocol provides an international standard for measuring blister rust infection.*

White pine blister rust was inadvertently introduced to both eastern and western North America in the early 20th century and has spread throughout the range of western five-needled white pines. It has reached as far south as the Sierra Nevada of California and the Sacramento Mountains of New Mexico, as far east as the Black Hills of South Dakota, and throughout the coastal ranges of British Columbia and the Rocky Mountains of Canada to the northern limit of white pines. Only parts of the Great Basin and "sky island" ranges of southeastern Arizona and southwestern New Mexico remain free of the disease. Though dependent on years with climate favorable to spore production, blister rust continues to spread and seriously threatens western forest biodiversity.

This fungal disease may result in the extirpation of several important subalpine-zone and tree-line species, including whitebark pine and limber pine, from western national parks. Of all pines impacted,

White pine blister rust is an invasive fungal pathogen native to Eurasia that infects only five-needled white pines. It often kills canopies where seed and pollen cones are produced before it kills entire trees, rendering them nonreproductive for years before they die.

In 2005 the Whitebark Pine Ecosystem Foundation developed and tested a field protocol for monitoring white pine blister rust. In most areas of the northern Continental Divide ecosystem, more than 70% of whitebark pine are infected with the fungal disease. In Glacier National Park and on the Blackfeet Reservation, whitebark pine mortality can be as high as 100%. Across the range, blister rust infection levels are now 40% or higher except for the interior Great Basin ranges, the southern Sierra Nevada, and the greater Yellowstone area. According to recent surveys, blister rust now infects about 19% of whitebark pines in the greater Yellowstone area.

however, whitebark is one of the most susceptible to the disease. It is found in all western high-elevation national parks except Rocky Mountain National Park, Colorado, where limber pine occurs instead. Whitebark pine is a keystone species throughout its range, reducing soil erosion and protracting snowmelt at high elevation, pioneering after fires and paving the way for regeneration of other species, providing habitat at high elevation, and supplying wildlife food in the form of large nutritious seeds. In the greater Yellowstone area, whitebark pine seeds are an important food for grizzly bear (*Ursus arctos*) and black bear (*Ursus americana*) prior to hibernation.

Though the database and protocol are only a first step in addressing the blister rust problem, they are important milestones for land management agencies in North America. They standardize and integrate data, fostering cooperation and information sharing and enabling a holistic response to natural resource threats on federal lands and across an international border. ■

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## Combating the hemlock woolly adelgid in Great Smoky Mountains National Park

*By Tom Remaley and Carey Jones*

**AT GREAT SMOKY MOUNTAINS** National Park (Tennessee and North Carolina) the results of insecticidal treatments of hemlock woolly adelgid (*Adelges tsugae*) have been dramatic. Hemlock woolly adelgid is a small aphid-like insect native to Asia that feeds at the base of hemlock needles and can cause tree mortality in as few as three years. Trees with ashen-gray foliage before treatment recover their color and produce new growth. Treatments include spraying insecticidal soap on trees in developed areas and along roadways, applying systemic insecticides directly to the soil, and injecting insecticide into the trunks of especially large trees or those inaccessible by vehicle. Additionally, park biologists released a predatory beetle (*Sasajiscymnus tsugae*) as a biological control in 78 areas with old-growth eastern hemlock (*Tsuga canadensis*) stands throughout the park. This and other biocontrols currently under development provide the best hope for control of the adelgid and survival of the hemlock forests. Supported by funds from the Friends of Great Smoky Mountains National Park, USDA Forest Service, and National Park Service, park managers (with a 12-member crew) treated more than 2,000 acres (810 ha) in 2005; they have aggressively managed the insect since its discovery in 2002.

*"Without the Friends of the Smokies and [other] supporters … we might not have the option of bio-control, which provides the greatest hope … for a permanent resolution [to] the invasion of the hemlock woolly adelgid."*

—Dr. Carl Jones, Department of Entomology and Plant Pathology, University of Tennessee

Investigators have now identified hemlock woolly adelgid throughout Great Smoky Mountains National Park. The insect has the potential to eliminate hemlock trees from the landscape; by comparison, almost 95% of the hemlocks in Shenandoah National Park have been lost to the infestation. Great Smoky Mountains National Park contains more than 800 acres (324 ha) of old-growth eastern hemlock, the most of any unit in the National Park System. Hemlock forests are widely distributed over almost 90,000 additional acres (36,450 ha) in the park. Some of the largest eastern hemlocks known, commonly exceeding 150 feet (46 m) tall and as much as 6 feet (2 m) in diameter, inhabit the park.

Although the adelgid will fundamentally and forever alter the hemlock forests of the Smokies, with continued funding, dedicated staff, and committed partners, future visitors to the park will still be able to marvel at the "redwood of the East." Public education has led to significant fundraising for control of hemlock woolly adelgid, including efforts that involve the Great Smoky Mountains Association, Friends of Great Smoky Mountains National Park, and local schools, civic groups, and businesses. These fundraising efforts prompted the establishment of an additional beneficial insect lab at the University of Tennessee, funding of field crews, and provision of supplies and equipment. A prime example

In addition to spraying insecticidal soap on trees to combat hemlock woolly adelgid, public education is a strong part of control efforts at Great Smoky Mountains National Park. Outreach includes TV, radio, and newspaper progress reports; the Save Our Hemlock Web site at http://saveourhemlocks.org; presentations to local civic clubs; community and teacher workshops about controlling the adelgid; ranger-led public hikes that study the insect in the field; educational handouts and posters distributed in the park and neighboring communities; and, of course, word of mouth from the many citizens who support the efforts to control infestations in the park's hemlock forests.

of partner support is the Great Smoky Mountains Association's creation of a "Save the Hemlocks" T-shirt. In 2005 the public sale of this item generated $70,000, all devoted to raising beetles at the University of Tennessee lab. (The sale of each shirt pays for about a dozen predator beetles.) The integration of public education in this program illustrates how outreach and awareness can result in financial and procedural support for addressing a serious natural resource threat. ■

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# Avian influenza: What is the threat to our national parks?

*By Margaret A. Wild, David Bleicher, and Charles Higgins*

**THE NATIONAL PARK** Service's Public Health, Risk Management, and Wildlife Health Programs are working closely with other NPS programs and federal agencies in planning for surveillance and response to the Asian strain (H5N1) of highly pathogenic avian influenza (HPAI). A top news story for 2005, avian influenza, known as "bird flu," was responsible for 94 laboratory-confirmed cases of human disease, with 41 human fatalities. At present, however, the disease primarily affects domestic and wild birds and has not acquired the ability for sustained human-to-human transmission, though this possibility is a real concern. In order to control spread of the disease, authorities in affected countries culled millions of domestic poultry, ducks, and geese. Yet what impact might this disease have on the staff, visitors, and wildlife in our national parks?

*Although the media has given ample coverage to the threat of disease spread by migratory birds, human-assisted movement of domestic or wild birds, particularly illegal movement, is likely to be a more serious threat.*

Avian influenza viruses occur naturally in birds, particularly those living in and around water. Some avian influenza viruses cause no ill effect in birds; a percentage of wild birds worldwide carries these low-pathogenic avian influenza viruses. However, the Asian strain of H5N1 has mutated in infected domestic birds to become pathogenic to birds, humans, and some other mammals. Because of these changes, the National Park Service would consider the virus to be an exotic organism if introduced into US national parks.

Though the highly pathogenic H5N1 strain has not been identified in North America, the threat of introduction looms with its spread in Asia and eastern Europe. The three most likely routes for its introduction into the United States are migratory birds, human-assisted movement of wild or domestic birds, and human-human transmission. If migratory birds were to introduce HPAI into this country, the virus would probably arrive first in Alaska with birds from Asia in the spring. Infected birds from Asia could then mix with birds from other flyways that share summer grounds in Alaska. In fall these birds could carry the infection down flyways to the lower 48 states. Although the media has given ample coverage to the threat of disease spread by migratory birds, human-assisted movement of domestic or wild birds, particularly illegal movement, is likely to be a more serious threat. This type of introduction could occur at any place or time. Finally, if sustained human-to-human transmission develops, persons entering the United States could introduce HPAI into this country.

Though avian influenza has not been identified in North America, bird migration from Asia to Alaska, and in turn from Alaska to the lower 48 states, is a plausible way for the virus to be introduced into the United States. In 2005 the National Park Service emphasized planning for surveillance and response to the pathogenic strain of the disease in order to protect human and wildlife health in national parks.

Although public health officials do not know if an avian influenza pandemic will occur, biologists predict that if HPAI reaches this country, mortality in both domestic and wild birds will almost certainly occur. The level of mortality and the species of wild birds that would be affected are not known. However, based on other avian influenza subtypes, biologists expect HPAI to affect primarily waterfowl such as ducks, geese, and swans, and to a lesser extent, shorebirds such as gulls. Although no data suggest that culling wild birds would control an outbreak, significant public or political pressure may build to "do something," but this type of control effort in wild bird populations is not logistically or environmentally feasible.

So what can be done? In wildlife management, surveillance for H5N1 in wild birds is important and is best accomplished by being alert to and investigating unusual mortality events. Field biologists can decrease the risk of HPAI by reducing inhalation of aerosols such as dust, feathers, or dander; wearing personal protective equipment; and washing hands and disinfecting equipment after use. Park staff should encourage visitors to enjoy wildlife from a distance, and in

particular, not to touch dead animals but instead report them to natural resource managers.

Should HPAI gain the ability for sustained human-to-human transmission, the National Park Service could implement a number of tools for managing an avian influenza pandemic. Simple hygienic preventive measures like coughing into one's sleeve and washing one's hands would become critical in a disease outbreak. Park operations could be significantly impacted in response to a pandemic, including the potential for park closures, implementation of public access and interaction policies, restrictions on movements and the use of law enforcement to enforce these restrictions, and the need for protection of emergency medical system providers. Other methods of disease control could include isolation of sick individuals, quarantine to limit the movement of all individuals, education of the public and park employees, use of antiviral agents, and vaccination if an effective vaccine is available.

Regardless of whether a pandemic occurs, information and knowledge will facilitate prudent planning and preparation, allowing the National Park Service to be prepared to protect park natural resources and employee and visitor health. More information about avian influenza and NPS response planning is available at http://www.nps.gov/public_health/zed/ai/ai.htm. ■

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# Earthworms return to forests of the western Great Lakes region

*By Suzanne Sanders*

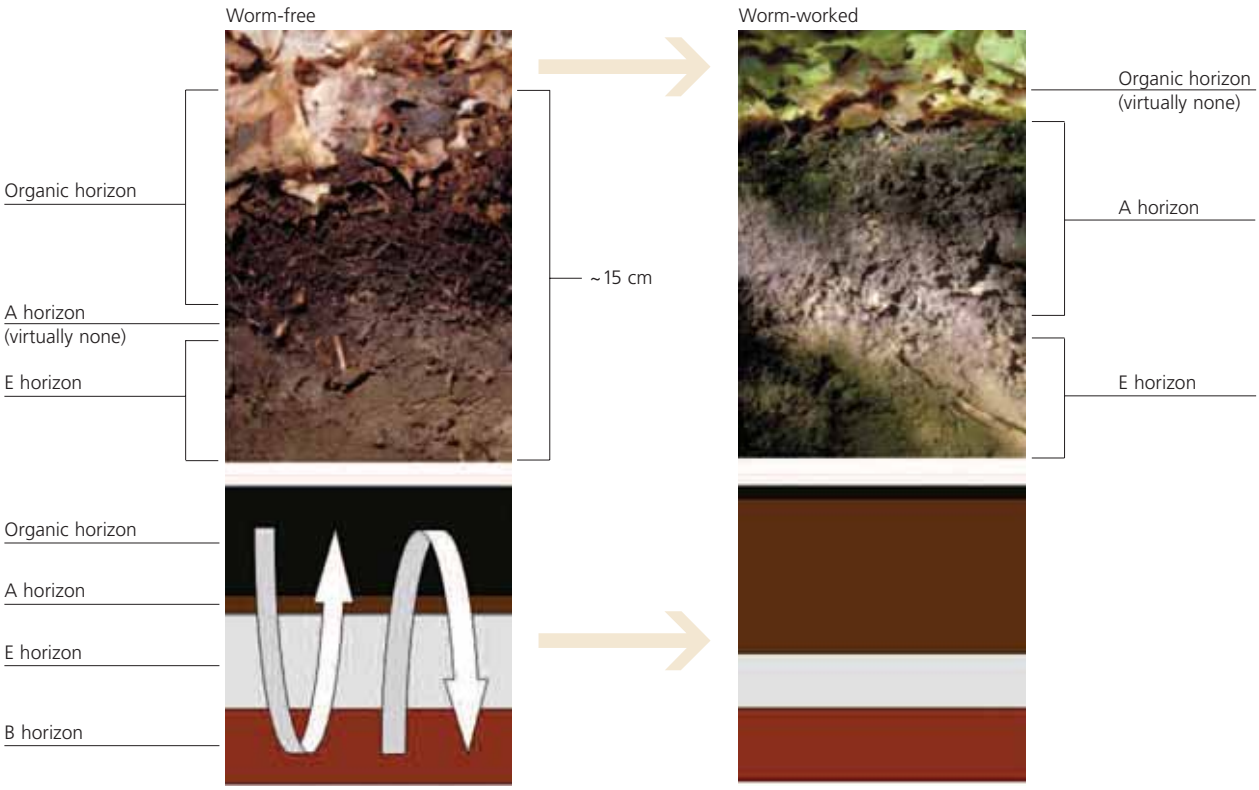
**MOST PEOPLE ARE SURPRISED TO LEARN** that earthworms are not native to many areas of the northern United States, including parts of Minnesota and Michigan. Scientists assume that earthworms were once native to this region but disappeared during the last ice age when glaciers covered a large part of the continent. Now the earthworms are working their way back, introduced in part by anglers. Research has documented the impact of exotic earthworms on sugar maple forests, but little is known about their effects on other forest types. The Great Lakes Inventory and Monitoring Network funded a two-year study (2004–2005) to inventory exotic earthworms in beech-maple forests at Pictured Rocks National Lakeshore (Michigan) and in aspen-fir forests at Voyageurs National Park (Minnesota), and to test for relationships among earthworms, soil characteristics, and plant communities. The study was carried out by Cindy Hale and George Host of the Natural Resources Research Institute of the University of Minnesota.

*Scientists assume that earthworms were once native to this region but disappeared during the last ice age when glaciers covered a large part of the continent. Now the earthworms are working their way back, introduced in part by anglers.*

Earlier research had shown that earthworms change the soil in the top three layers of the soil profile. Forest soils that formed in the absence of earthworms have a thick, organic surface layer. Below it is the "A horizon," a mineral-mixed-with-humus layer that in this environment is characteristically thin, and underlying it is a leached, sandy loam layer, the "E horizon." This profile supports diverse plant communities adapted to these soil conditions. However, earthworms mix the soil horizons so that the organic layer above and the E horizon below are incorporated into and expand the A horizon. In sugar maple forests this soil disturbance impacts the understory plant community and may facilitate the establishment of invasive plants, an area of future research.

Investigators in the Great Lakes Network study found that only 3 of 40 sites sampled were free of earthworms, despite the fact that 20 sites were predicted to be at low risk for invasion. Five earthworm species were found in both forest types, though the total earthworm biomass in the aspen-fir forests was only about half that in the beech-maple forests. This earthworm biomass, in turn, was approximately half that reported for sugar maple forests by other researchers. In addition, this study found that where earthworm species richness and biomass were greatest, the organic horizon was thin and the underlying A horizon was thicker, supporting the results of other investigations. In contrast to the results of research in sugar

SOIL PROFILES, VOYAGEURS NATIONAL PARK, MINNESOTA




The introduction of earthworms in two kinds of northern forests threatens native understory plants by changing the soil profile. The soil before earthworms arrive has a thick organic layer at the surface, underlain by a thin mineral-mixed-with-humus (A horizon) layer, underlain by a leached, sandy loam layer.

Earthworms mix these layers, creating a thick A horizon at the expense of the other two layers. The resulting soil is less hospitable to the native understory, possibly rendering it vulnerable to exotic invasive plants, a situation of concern to managers.

maple forests, however, this study did not find adverse impacts on forest understory plant communities.

The presence of earthworms at the two parks is widespread, although the herb-layer diversity suggests that invasion occurred relatively recently. One key aspect of earthworm spread is that it is slow, averaging only 16 to 32 feet (5 to 10 m) per year. The most effective management policy is one that emphasizes minimizing the establishment of new inoculation points for earthworms through a combination of public education and increased enforcement of regulations. ■

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# Coral bleaching and coral disease: A damaging combination for reefs in Virgin Islands National Park

*By Jeff Miller and Matt Patterson*

**WHILE A RECORD NUMBER OF TROPICAL STORMS** and hurricanes battered coral reefs in Florida and the Caribbean in 2005, below the surface two forces combined into a "perfect catastrophe" scenario for coral reefs. Outbreaks of the coral disease "white plague" occurred as a Caribbean-wide coral bleaching event produced extreme levels of coral mortality. Monitoring in 2005 revealed extensive coral bleaching and disease-caused coral mortality at sample sites in Virgin Islands National Park and Buck Island Reef National Monument. Scientists with the South Florida/Caribbean Network (SFCN) monitor coral reefs in four parks in the Southeast Region: Dry Tortugas, Biscayne, and Virgin Islands National Parks, and Buck Island Reef National Monument. South Florida parks escaped the bleaching occurring in the Virgin Islands parks in part because of cooler water temperatures that accompany the passing of tropical storms and hurricanes.

*Corals bleach in response to stress, and in 2005, record high water temperatures caused this to occur in coral reefs around the US Virgin Islands.*

An ongoing, eight-year monitoring program at Tektite reef in Virgin Islands National Park looks specifically at white plague. Average live coral-cover on the study transects at Tektite reef has declined by 46.7% (from an annual average of 66.5% in 1997 to 44.5% in 2005). Compounding the problem, this disease principally affects the most abundant and major reef-building coral species, star coral (*Montastraea annularis*), which grows extremely slowly at 0.04 to 0.08 inch (1 to 2 mm) per year and has very low recruitment (coral larval settlement and growth) rates. In addition to long-term monitoring, network scientists work with universities and groups such as the Coral Disease and Health Consortium to determine the drivers of coral diseases. US Geological Survey (USGS) scientists focus on disease etiology, including experimental, nondestructive sampling techniques in which investigators take swabs of healthy and diseased coral tissue, which are later analyzed for microbial communities and coral genotypes.

Coral bleaching began in late summer and continued into December 2005. This bleaching occurs when the symbiotic algae within the coral tissue are expelled. These algae, called zooxanthellea, provide the coral with energy and its greenish brown color. When the algae are expelled, the coral loses its color, appearing white or bleached. Corals bleach in response to stress, and in 2005, record high water temperatures caused this to occur in coral reefs around the US Virgin Islands. Long-term effects of the bleaching depend upon duration and severity (i.e., complete or partial loss of the zooxanthellea). The last bleaching event to affect this area occurred in 1998 and caused low levels of coral mortality. However, researchers are concerned that record warm water temperatures in August and September 2005 may make this bleaching episode more severe than the one in 1998.

Bleaching of *Montastraea annularis* and *Porites porites* (head corals, facing page, left column) started in August 2005, but corals showed partial recovery by October 2005. By contrast, bleaching caused complete mortality of an *Acropora palmata* (elkhorn coral) colony (right column) by 26 October 2005.

As of November 2005, color was returning to the "head" corals (*Montastraea*, *Colpophyllia*, *Diploria*, and *Siderastrea* species), indicating that mortality from bleaching may be low. The November white plague disease outbreak, however, has caused tremendous mortality to these same species that seemingly survived the bleaching. Whether the bleaching has made them more vulnerable to the disease is not yet known. Also, elkhorn coral, a species that is rarely affected, bleached during this severe event and has incurred substantial mortality. The elkhorn and staghorn corals (Caribbean *Acropora* genus) have been recommended for protection under the Endangered Species Act, a highly unusual occurrence for marine invertebrates.

In a year of record levels of storm activity, coral reefs were under attack from more than just hurricanes; coral disease and coral bleaching from elevated water temperatures combined with hurricanes to cause extensive coral mortality. Continued monitoring will document the total amount of mortality. As scientists with the South Florida/Caribbean Network continue to gain understanding of coral bleaching and disease, future endeavors may provide ways to mitigate these stresses and promote a more resilient coral reef ecosystem. For example, the Coral Reef Task Force—established in 1998 by presidential executive order to lead US efforts in preserving and protecting coral reef ecosystems—passed a resolution to take action in response to the 2005 Caribbean bleaching episode. These efforts are significant because not only do coral reefs attract millions of visitors to the National Park System each year, they serve as structural barriers that protect our shorelines from storm-generated waves. ■

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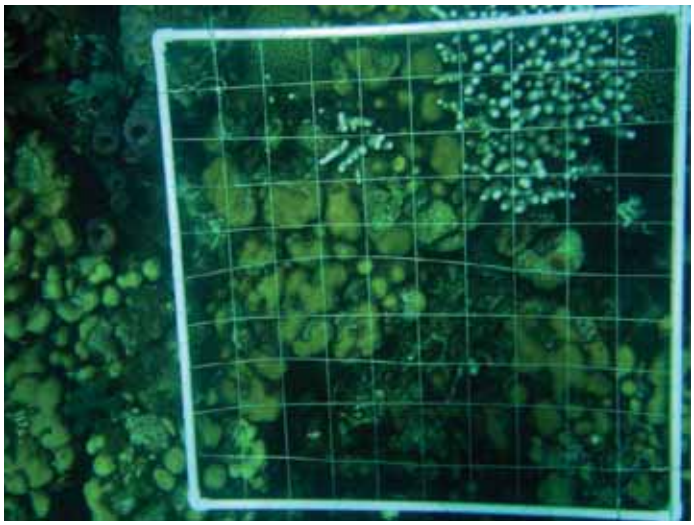

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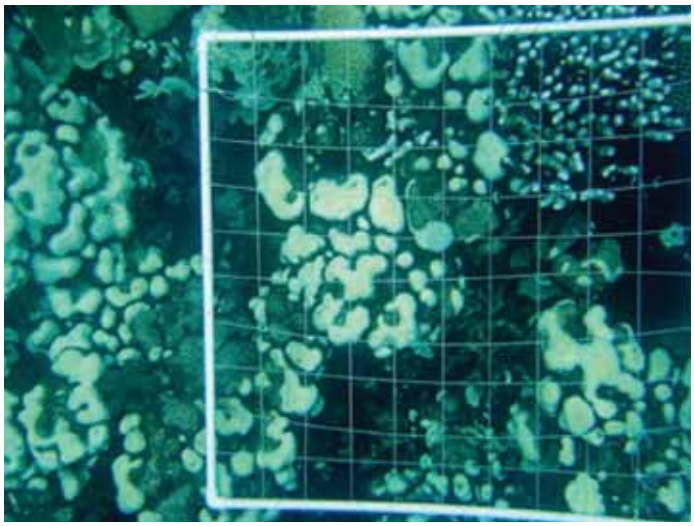

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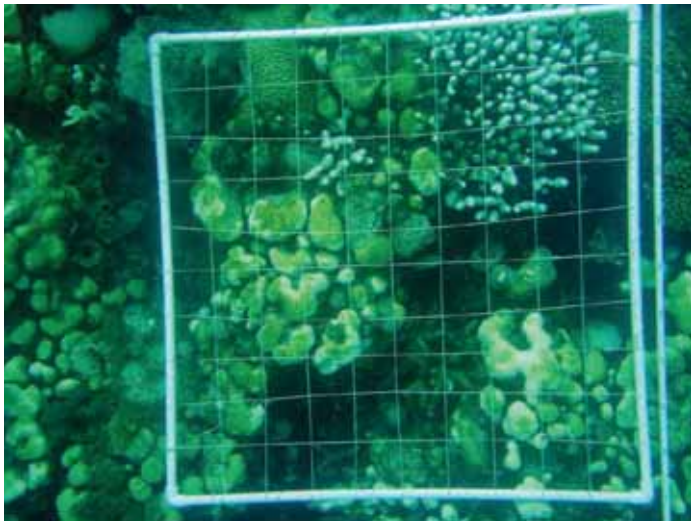

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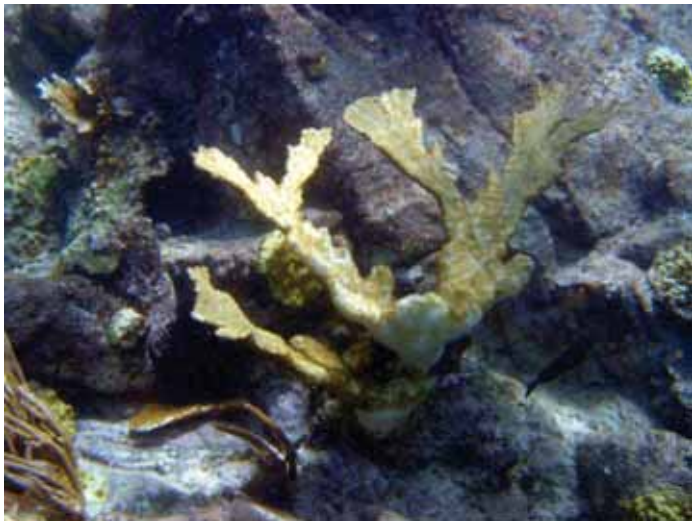

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# 5 Ecological Restoration

When natural resources in the national parks become damaged and degraded, resource managers turn to restoration as a way to repair ecosystems and return

native species and natural processes to the landscape. Restoration essentially takes the next step after eliminating the cause of the problem: removing nonnative species, cleaning up pollution, stopping illegal activities or inappropriate park uses, and others. It attempts to reestablish natural function where it was hampered so that park ecosystems can sustain themselves once again. The efforts to achieve these goals, as many of the articles in this chapter illustrate, go beyond making

mechanical changes in landforms and technical arrangements of species in a particular setting.

> *"Like the preservationist, … the restorationist aims for the ideal of a self-sufficient ecosystem, doing everything possible to let the system be, to turn it back into itself. Unlike the preservationist, however, the restorationist recognizes that the ideal of nature separate from humans "is a fiction."* — **William R. Jordan, III**

They integrate research to understand natural processes and relationships among the resources, and how each has been influenced by land use history. They demonstrate teamwork in project execution that incorporates creativity and precision. Moreover, they share ways in which people—National Park Service

staff, partners, contractors, and volunteers—apply many of these principles to restore natural integrity and function to damaged natural areas in the parks. Though for every project described herein many more are undoubtedly needed, the following stories give hope for a National Park System that will retain its special character, diversity, and appeal, and even take on

new meanings.

# Coastal dune restoration at Point Reyes pays off for three federally listed species

*By Jane Rodgers and Dawn Adams*

**URBANIZATION AND INVASIVE NONNATIVE PLANTS** have fragmented and eliminated coastal dune habitats. Along the west coast of the United States, coastal dunes are just 10% to 40% of their original distribution, according to ecologists. The problem has become so severe that whole communities of species that consistently occur together—invertebrates, birds, and plants—are now listed as threatened and endangered. To reverse this trend, Point Reyes National Seashore in California has cleared approximately 45 acres (18 ha) of dunes of European beachgrass (*Ammophila arenaria*) and other invasive plants as of FY 2005 to restore natural processes and improve habitat for federally listed species. By the end of the calendar year, monitoring results showed that dune restoration has paid off for at least three species listed as threatened or endangered.

In partnership with Point Reyes Bird Observatory Conservation Science, a park partner, the national seashore has monitored the threatened western snowy plover (*Charadrius alexandrinus nivosus*) since 1986. Dunes altered by invasive plant species restrict plover nesting to a narrow strip of sand between the beachgrass-formed seawall and the high tide line. Removing the beachgrass creates open space, providing chicks with large, navigable areas to forage, avoid predators, and stay away from human disturbance. Plover chicks are camouflaged in open sandy areas with their light, speckled coloring; well-placed driftwood spread by volunteers provides additional hiding places for the vulnerable young birds. Since March 2004, three nests have been discovered in restored dunes, the first ever seen in these areas. In 2005, following additional beachgrass removal, biologists documented male plovers moving chicks into restored areas for rearing purposes from nests as far away as 1.5 miles (2.4 km). More than half of the chicks fledged in the 2005 breeding season were reared in the restored sites.

*Nine species of native dune plants have reappeared within the restored area, making active revegetation unnecessary.*

In the spring the two endangered dune plants, Tidestrom's lupine (*Lupinus tidestromii*) and beach layia (*Layia carnosa*), naturally recolonized newly restored sites. In an area recently restored using heavy equipment, nearly 200 lupine and 18 layia seedlings were growing, presumably from newly exposed seed. Nine species of native dune plants have reappeared within the restored area, making active revegetation unnecessary.

Urbanization and nonnative plants have reduced coastal dune habitats to 10% to 40% of their original distribution along the west coast of the United States. As of FY 2005, Point Reyes National Seashore has cleared approximately 45 acres (18 ha) of dunes of European beachgrass and other nonnative plants to restore natural processes and improve habitat for federally listed species.

The Pacific Coast population of the western snowy plover has been federally listed as threatened since 1993. Restored dunes at Point Reyes National Seashore have improved habitat for the plover. More than half of the chicks fledged in the 2005 breeding season were reared in sites cleared of nonnative plants.

The dune restoration effort has taken four years and relied on support from the Natural Resource Preservation Program and Natural Resource Damage Assessment Program (NRDA) oil spill funds. Monitoring of pre- and postrestoration conditions has been a critical measure of project success. The data for listed species show that, "if you build it, they will come," and indeed they did. The early positive results have encouraged the national seashore to expand dune restoration activities. Point Reyes National Seashore will embark on an ambitious effort to restore 300 acres (122 ha), which represents approximately half of the dunes in need of restoration. Funds for the expanded restoration activities will be contributed by the NRDA, local nonprofits, and the NPS line-item construction program. The timing could not be better. ■

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# Collaboration key to Snake River embankment restoration at Grand Teton

*By Susan E. O'Ney*

**IN 2005, GRAND TETON NATIONAL PARK** coordinated a successful collaborative effort to stabilize a section of the Snake River near its park headquarters in Moose, Wyoming, using state-of-the-art bioengineering techniques. In response to 1997 flood conditions, the west bank of the river eroded as much as 5 feet (1.5 m), which caused concern for park facilities. This area is highly visible to park visitors and offered a great opportunity to design an informative demonstration project, illustrating the use of innovative restoration and stabilization techniques in lieu of the typical bank armoring. The techniques used to restore area riparian vegetation and fish habitat included a combination of brush and rock barbs, vertical willow bundles, brush revetments (retaining walls made of brush), pole plantings, and brush mattresses. In a park setting, these techniques are much more appropriate (not to mention more aesthetically pleasing) than armoring the banks with large boulders, as had been done in the past.

The success of this project was due largely to successful partnerships and collaboration. Funding came from a combination of sources, including the National Park Service Cooperative Conservation Initiative ($10,000), Grand Teton National Park Franchise Fee ($100,000), Jackson Hole One-Fly ($5,000), and Teton County Conservation District ($5,000 in-kind). The Natural Resource Conservation Service provided the expertise to design and implement bioengineering techniques to restore riparian vegetation. In-kind participation of park personnel was critical to the collection of native materials and project supervision and oversight.

*This area … offered a great opportunity to … use … innovative restoration and stabilization techniques.*

In May 2005 the park conducted a three-day Riparian Ecology and Restoration Workshop at the restoration site. During the first half of the workshop, attendees participated in classroom exercises. During the second half of the workshop, attendees, other community volunteers, and personnel from neighboring agencies and sister parks completed the hands-on bank stabilization work. The Teton County Conservation District provided lunch for attendees, handled workshop logistics, and coordinated collection of native plant materials, including logging slash for the brush revetments and live willow cuttings. Collected by volunteers from the Teton Science School, the willow cuttings provided the materials for the vertical bundles, brush barbs, pole plantings, and brush mattress.

Results have been spectacular. Plantings experienced a 95% success rate and sediment deposition is rapidly occurring along the riverbank. Streambank vegetation, bank stability, fish habitat, and aesthetics have all been improved along this reach of the Snake River. This project is an outstanding example of how innovative streambank bioengineering techniques could be used in similar situations throughout the National Park System. ■

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To stabilize the west bank of the Snake River, Grand Teton National Park cooperated with numerous organizations and agencies: the Teton County Conservation District; the Teton Science School; the Natural Resource Conservation Service (NRCS) National Design Construction and Soil Mechanics Center in Fort Worth, Texas; the NRCS Plant Materials Center in Aberdeen, Idaho; the NRCS in Casper, Wyoming; Rendezvous Engineering (a local engineering firm); Grand Teton Lodge Company (a park concessionaire); Jackson Hole One-Fly; and the National Fish and Wildlife Foundation. Here, workshop participants are installing a brush mattress from live willow stakes to protect the streambank from erosion.

Success! Sediment deposition along the brush revetment (left) and willow growth from pole plantings and vertical bundles (right) offer a more gentle slope along the west bank of the Snake River at Moose, Wyoming, after the stabilization and restoration project.

# First-time restoration prompts return of seagrass to Biscayne National Park

*By Kim Olsen and Tammy Whittington*

**WETLAND RESTORATION** may be a familiar if technical activity of the National Park Service on terra firma, but imagine restoring vegetation on the ocean floor! Until recently the National Park Service had never attempted this kind of restoration. However, vessels running aground in shallow waters of Biscayne National Park (Florida) have damaged plants known as seagrass in several park locations, necessitating a plan for their restoration. Seagrass includes turtle grass (*Thalassia testudinum*) and shoal grass (*Haldule wrightii*) and serves an important function as nurseries for fish and other marine life. Injuries to these native plants occur when boat operators attempt to power off or free themselves from their predicament, and in the process propellers create trenches and "blowholes" in the delicate ocean floor material where seagrass grows. In 2002 and 2004 the National Park Service and its partners restored three sites where seagrass had been injured by boat groundings. By May 2005, signs of recovery were evident, signaling a breakthrough for the National Park Service in this new restoration activity.

The restoration sites were named for the three vessels that had injured the seagrass: *Pure Pleasure*, *She's a Lady,* and *Tom's Tug.* Authorized by the National Park System Resource Protection Act (16 USC 19jj), the National Park Service has been able to recover damages from the responsible parties to fund the restoration. The restoration process began in September 1999 when a multidisciplinary team from Biscayne National Park, the Restoration Unit of the NPS Environmental Quality Division, and contractors from Tetra Tech EC, Inc., and Marine Resources, Inc., planned the project. The group determined its scope, acquired permits, and defined criteria for evaluating success. The Final Restoration Plan (December 2003) guided the restoration based on the type of injury at each site, and the Final Completion Report (October 2004) documents the methods.

*By May 2005, signs of recovery were evident, signaling a breakthrough for the National Park Service in this new restoration activity.*

The Pure Pleasure site consisted of two propeller scars. The restoration team backfilled the site with approximately 1 cubic yard (0.8 cu m) of sediment, which was batch-mixed by a concrete mixer and shoveled into 45 burlap bags. The sediment included fine silica sand, diatomaceous earth, calcium carbonate sand, and an organic material added at 5% by weight. After placing the bags into the trenched areas, the team slit them to allow water to flow freely around them and distribute the sediment. In June 2005 the

By May 2005 the site was beginning to recover with new seagrass growth visible around "bird" stakes. The stakes were placed to encourage roosting and natural fertilization of the restoration site by waterbirds.

Seagrass restoration at Biscayne National Park involved placement of sediment-filled burlap bags in trenches where powerboats had run aground and their operators had attempted to free themselves from shallow water. The Tom's Tug site is the largest of three restoration areas and is shown immediately after placement of the bags in June 2004.

By May 2005 a transplanted seagrass plug had begun to recruit new growth at the restoration site.

site had stabilized, the burlap had begun to degrade, and natural recruitment of shoal grass was documented to approximately 15% cover.

Restoration of the She's a Lady site was similar and required backfilling three propeller scars. The sediment material used at this site consisted of calcium carbonate sand, lake fill, masonry sand, and organic material added at 7% by weight. The mixture was loaded into approximately 140 burlap bags, totaling 3.1 cubic yards (2.4 cu m), which the contractor placed into the trenches, again slitting them on the sides. In addition, they placed 13 "bird" stakes and two "No Boating" signs at the site. The stakes are intended to encourage waterfowl roosting and the deposition of natural fertilizer onto the restored areas. In May 2005 the injured areas had recovered to about 5% turtle grass and 15% shoal grass cover. Although this site was located in an area of strong current and extreme wave action, restoration was successful.

The Tom's Tug blowhole was the largest restoration site and required 375 bags of sediment, or 8.4 cubic yards (6.4 cu m), placed in the same manner and with the same mixture as at the She's a Lady site. Six bird stakes and one "No Boating" sign were also installed. Approximately 45 days after the sediment-filled burlap bags settled into the trenches, the team harvested 42 plugs of turtle grass from a nearby healthy seagrass bed for transplanting at 1.6-foot (0.5 m) intervals throughout the injured site. In May 2005 the project team was elated to discover large areas of new plant growth and survival of the transplanted seagrass plugs. The burlap bags have degraded and the area is now about 70% covered with the turtle grass, recruited shoal grass, and manatee grass (*Syringodium filiforme*).

These three seagrass restoration projects are the first for the National Park Service. Though they appear to be successful, the sites will continue to be monitored. Planning was strenuous and time-consuming; however, the field results for restoring this critical habitat have proven to be very encouraging, and the planning documents are now being used to guide restoration of other seagrass sites in the park. ■

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# Joshua Tree National Park disguising closed roads to protect fragile desert ecosystems

*By Paul DePrey and Margaret Adam*

**SOMETIMES OLD ROADS ARE MORE INVITING** than the National Park Service would like, especially in fragile desert ecosystems where they remain visible for decades after they are closed. By 2005, Joshua Tree National Park, located in the heart of the desert in southern California, had successfully "disguised" miles of closed dirt roads, effectively deterring unwanted and illegal use that slows down the natural restoration process.

Many roads in the national park, most left over from historical mining and homesteading activities, were closed to motorized use when Congress designated the area as wilderness in 1994. Where these old roads are still visible, some people continue to use them. This is especially true where boundary marking is unclear (leading to confusion) or where ranger patrols are intermittent (leading to temptation). Whatever the reason, this activity reinforces the visible scar, prevents revegetation, contributes to erosion, and may lead to new damage to park resources.

*Stopping illegal traffic prevents damage and allows natural revegetation to progress.*

Nearly 150 roads are closed within the park, ranging from tracks nearly obliterated by natural regrowth to areas repeatedly marred by illegal off-highway vehicle use. Management in this area consists of two primary goals: protecting resources and stopping illegal driving. To achieve these objectives the strategy is to obliterate the appearance of roads in order to reduce the visual scar and eliminate the temptation to drive on them. Stopping illegal traffic prevents damage and allows natural revegetation to progress. This helps restore the natural plant community and decrease erosion.

The most effective technique for disguising closed roads at Joshua Tree National Park is vertical mulching. This process involves planting dead vegetation (taken from nearby areas) to simulate living shrubs. In addition to blocking access, the technique encourages natural regrowth by providing shelter from sunlight and protection from wind for seeds and seedlings. Other road-closing techniques are installation of posts or fencing, strategic placement of boulders, planting seeds, transplanting existing plants, recontouring the road surface, and scattering rocks along it.

Managers have developed a protocol to help them determine the effectiveness of vertical mulching in restoring the fragile Mojave and Colorado Desert ecosystems within the park. This protocol includes using belt transects (surveying the area at regular intervals) to measure the amount and type of species that occur within the area. It also includes testing soil crust for structural integrity and comparing treated and untreated areas. Initial monitoring visits have been completed at more than a dozen sites and will continue at sites in each of the vegetation communities in the park.

Old roads at Joshua Tree National Park are being rehabilitated to disguise or clearly mark them as closed so they will not be mistaken as legitimate driving routes. Park staff has applied a technique of "vertical mulching," or planting dead vegetation and spreading rocks, so that barren areas will blend into their desert surroundings and begin the process of natural revegetation. Boulders and "no motor vehicles" signposts are also employed as needed.

By 2005, more than 120 sites were successfully rehabilitated. In addition, following a process to identify sensitive cultural resources, park staff has secured clearance to add a dozen more sites to the program. Periodic visits to these rehabilitated sites have revealed few incidences of trespass or damage, indicating that the disguise is working and that the program is effectively ending the "invitation" to drive over fragile, but now healing, park resources. ■

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# Ladders, lint, bridges, and rubble: Cleaning up Carlsbad Cavern

*By Paul Burger*

**WITH THE HELP OF VOLUNTEERS AND PARTNERS** in 2005, park staff removed six structures, more than 20 tons (18 metric tons) of rubble, and many pounds of lint from Carlsbad Cavern, New Mexico. More than 100 years of trail development and visitation had severely altered the natural cave ecosystem. Past workers had buried more than 7,500 square feet (698 sq m) of natural cave floors with rubble from the construction of the underground lunchroom and the two elevator shafts that were blasted into the cave. This rubble, along with rock and dirt removed from other areas of the cave, was used to fill in low areas. However, it buried the natural cave floors and altered the habitat of the invertebrates and other cave animals that lived there. In some off-trail areas, the National Park Service had placed more than a dozen ladders and bridges to make travel easier. Wooden structures increased nutrient levels in the normally nutrient-poor cave system, resulting in overpopulation of cave crickets, other invertebrates, and microbes. Deteriorating steel structures introduced metals, which are harmful to native microbes, invertebrates, and other cave animals. In addition, around 350,000 annual cave visitors continue to deposit foreign materials such as lint, hair, paper, and food along the trail system. As these materials decompose, they create chemicals that damage and discolor cave formations.

*More than 100 years of trail development and visitation had severely altered the natural cave ecosystem.*

With a grant from the Cooperative Conservation Initiative and more than 2,000 volunteer hours, reversal of these impacts has begun. Grant monies have allowed park managers to purchase stainless-steel ladders, which do not add metals to the cave environment, and safety equipment for volunteers. Volunteers and staff, using shovels and wheelbarrows, removed tons of rubble, restoring more than 800 square feet (74 sq m) of natural cave floor. Workers dismantled and carried away one large, old wooden bridge and five steel walkways from selected areas of the cave—nearly half of the structures identified for removal. Resource specialists targeted structures and areas where continued deterioration was most pronounced and where highly qualified volunteers could be most effective. Many of the structures were in densely decorated areas of the cave, requiring technical skills for their removal without damaging the fragile cave formations or causing injury to workers. Additionally, volunteers used brushes and tweezers to painstakingly extract lint, hair, and other materials dropped in the cave by visitors.

Walkway area before and after restoration.

These efforts have resulted in restoration of approximately 10% of disturbed cave floor and habitat in the area around the old underground lunchroom. Volunteers and staff have minimized deterioration of cave decorations and walls along trails where they removed lint and trash. In addition, their labors have eliminated the primary sources of contaminants in off-trail areas of the cave, comprising nearly half the areas where deteriorating structures had been. These efforts are a tremendous start to the process of reversing some of the damage caused by infrastructure and visitation and of restoring habitat in Carlsbad Caverns National Park. ■

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# Diversifying bighorn sheep genetics at Badlands National Park

*By Eddie Childers and Teresa Zimmerman*

**THE FIRST-GENERATION PROGENY** of recently introduced and resident bighorn sheep at Badlands National Park, South Dakota, were born in spring 2005. In fall 2004, staff at Badlands, in cooperation with the South Dakota Department of Game, Fish, and Parks and the New Mexico Department of Game and Fish, captured and relocated to the park 23 bighorn sheep (10 adult ewes, 2 yearling ewes, and 11 lambs) from Wheeler Peak, New Mexico. These sheep are now helping repopulate the historical eastern range (i.e., parts of Montana, Wyoming, the Dakotas, and Nebraska) of the Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) that had been extirpated throughout much of this area by 1925. As of December 2005, 9 of 11 lambs were alive.

North American bighorn sheep are an ecologically fragile species. Human impacts over the last 150 years have led to major decreases in populations. Factors of decline include overgrazing, diseases introduced by cattle and domestic sheep, urban expansion, mining, logging, off-road vehicle use, unregulated hunting, competition with mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*), oil and gas exploration, usurpation of water resources, and fire suppression.

*In order to restore genetic diversity, scientists recommended population supplementation from another herd of Rocky Mountain bighorn sheep.*

In 1964, to restore this native ungulate to its former range, the National Park Service; the South Dakota Department of Game, Fish, and Parks; and the Colorado Division of Wildlife introduced 20 Rocky Mountain bighorn sheep from Pikes Peak, Colorado, to a 370-acre (150 ha) enclosure at Badlands. The goal of the project was to establish a captive breeding herd, which would allow relocation to other areas of suitable habitat in South Dakota. However, disease reduced the captive herd to 14 animals, which were then released into the park. The herd grew rapidly, but over the next 30 years a series of three diseases (epizootics) reduced the population from its peak of more than 140 individuals to fewer than 60.

Based on the estimated effective population size and the analysis of molecular genetic data, biologists determined that the bighorn sheep at Badlands had undergone a "population bottleneck" at founding. In order to restore genetic diversity, scientists recommended population supplementation from another herd of Rocky Mountain bighorn sheep. This led to the translocation in 2004, which is intended to provide both short- and long-term genetic contributions to the Badlands population.

With support from Badlands National Park, a PhD student from South Dakota State University has been monitoring the introduced animals since their arrival from New Mexico. The study is evaluating the restoration of the species at Badlands by tracking the genetic makeup of the offspring, determining initial parasite loads of the introduced sheep, and identifying habitat use and movements of the new subpopulation. Results from this project will benefit bighorn sheep managers in desert and alpine environments throughout the western United States, Canada, and Mexico, particularly where populations are in need of restoration or supplementation. A wide variety of federal agencies, 13 western state wildlife departments, and three organizations committed to the welfare of wild sheep will be able to use the results in restoring bighorn sheep to suitable habitat throughout their historical range. ■

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Bighorn sheep at Badlands National Park had reached a "population bottleneck." In September 2004, park staff and partners released 23 Rocky Mountain bighorn sheep from Wheeler Peak, New Mexico, to improve genetic diversity of the Badlands herd. Ten introduced ewes successfully lambed in spring 2005.

In order to monitor introduced bighorn sheep at Badlands, biologists fit the adults and yearlings with radio collars. As of June 2005, all the introduced bighorn sheep and 9 of 11 of the yearlings born in the park were alive.

# Klondike Gold Rush National Historical Park ensures success of the region's first wetland restoration project

*By Meg Hahr*

**YEARS OF UNRESTRICTED VEHICLE AND HORSE TRAFFIC** had significantly impacted a 1-acre (0.4 ha) wetland area known as Nelson Slough near the historic town site of Dyea, Alaska, today part of Klondike Gold Rush National Historical Park. From the 1950s through the late 1990s, local residents, visitors, and park staff forded Nelson Slough to reach the Taiya River tidal flats. Protection of the slough was identified as a priority in the late 1990s after the Alaska Department of Fish and Game documented the presence of salmonids in Nelson Creek and the importance of the slough's wetland complex as habitat for juvenile coho salmon (*Oncorhynchus kisutch*). Since that time, the park has worked with adjacent landowners to locate an alternate vehicle crossing and initiated a multiyear project to restore the slough in 2003. In 2005, park staff continued revegetation efforts, controlled nonnative plants, monitored project success, and met with local school groups to talk about wetland ecology.

*The Nelson Slough wetland restoration project is the first of its kind in the region.*

Today Dyea is a major archaeological site where visible remains of the gold rush include collapsed buildings, decaying wharf pilings, scattered artifacts, and the Slide Cemetery, where many victims of an 1898 avalanche are buried. The park was established in 1976 to preserve in public ownership historic structures and trails associated with the Klondike Gold Rush of 1898. Restoration of the slough not only enabled the park to protect aquatic resources but also allowed visitors to experience the history of the gold rush in a largely natural setting. In the late 1990s the park worked with state and local landowners to find an alternate route to the tidal flats, which resulted in the construction of a vehicle bridge downstream. Subsequently, the park built a narrow footbridge for hikers and closed the slough to horse tours because of concerns about poor water quality, invasive plants, and soil erosion.

In 2003 the park biologist used base funds to hire a local firm specializing in wetland and stream restoration to produce a restoration design for the site. In 2004 the park obtained approximately $20,000 from the NPS Water Resources Division to implement the restoration plan. The reconfiguration of the channel profile occurred over a two-day period and required large volumes of gravel and soil. Water quality monitoring was done before, during, and after the construction. Aquatic macroinvertebrates were also sampled at the site. Before work began, the inlet and outlet of the slough were fenced off and all fish were trapped and removed from the area so they would not be affected by construction activities.

Park crews transplanted wetland and upland plants from adjacent reference areas into the restoration site immediately after the reconfiguration of the channel. Revegetation efforts were carried out with the assistance of the Southeast Alaska Guidance Association, a work and training program for young adults. In the following year, very little mortality was observed for the approximately 200 native plants that were relocated to the site. However, the site was found to contain several species of nonnative upland plants. In 2005, park crews worked to control these nonnative plants by manually removing them. Native seeds were collected and planted at the site, which is subject to ongoing monitoring. An interpretive program began to take shape in 2005 when park biologists met with local school groups to talk about wetland ecology.


Years of unrestricted traffic had significantly impacted a 1-acre (0.4 ha) wetland area known as Nelson Slough at Klondike Gold Rush National Historical Park. Protection of the slough was identified as a priority in the late 1990s after the Alaska Department of Fish and Game documented the presence of salmonids in Nelson Creek and the importance of the slough's wetland complex as habitat for juvenile coho salmon.


In summer 2004 the park hired local contractors to reconfigure the slough. Construction activities occurred over a two-day period and required large volumes of gravel and soil. Before work began, the fish in the slough were trapped and removed from the area so they would not be affected.

Immediately following construction activities, park crews, with the assistance of the Southeast Alaska Guidance Association, transplanted wetland and upland plants from adjacent areas into the restoration site. Very little mortality was observed for the approximately 200 native plants that were relocated to the site.

By 2005 the site had begun to recover from restoration activities. Park staff worked to ensure the long-term success of the restoration by continuing to revegetate the area, controlling nonnative plants, and meeting with local school groups to talk about wetland ecology.

The Nelson Slough wetland restoration project is the first of its kind in the region. However, the Taiya Inlet Watershed Council, a newly formed interagency watershed stewardship partnership, has identified many similar areas in need of enhancement. The lessons learned at Nelson Slough may be valuable to other resource managers in other parts of the watershed in the future. With this in mind, park staff worked to ensure the long-term success of the restoration project in 2005. ■

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# Disturbed lands reclaimed at Prince William Forest Park

*By Jennifer Lee*

**VISITORS TO NATIONAL PARKS MAY EXPECT** to experience pristine landscapes preserved and protected from human despoliation. However, at some parks they will find landscapes that are recovering from previous damage as the parks reclaim and restore them. The boundary of Prince William Forest Park in Virginia contains 18,572 acres (7,522 ha), of which approximately 1,500 acres (608 ha) are private inholdings occupied by small businesses and homes. The National Capital Region and Prince William Forest Park have been actively acquiring lands within the park boundary from willing sellers. Two acquisitions, the Thomas tract and the Bradford tract, are sites of a project funded in 2004 by the NPS Natural Resource Preservation Program–Disturbed Lands. Of the combined 41 acres (16 ha) of the two tracts, 26.8 acres (10.9 ha) were forested and appeared to have been undisturbed by the former landowners, but 14.2 acres (5.8 ha) were in need of reclamation.

*[Reclamation included creating] a swale that would reconstruct the natural topography of the site, using adjacent topography and existing drainages to guide the design.*

These areas had been "human-disturbed" and the natural topography and drainage had been altered. The Thomas tract had been used primarily for single-family dwellings. Trash left by the former occupants littered the site and approximately 5,000 tires had been illegally dumped. The Bradford tract had been used as an unpermitted landfill that contained concrete, asphalt, and other materials. It also had a trailer park, an apartment building, and two single-family houses. These landscapes were barren and experienced a great deal of runoff during storms, causing erosion and sending sediment into Quantico Creek, although surveys and baseline groundwater data did not indicate the presence of any contaminants on either site. Much of the surface was open and level, sloping gently to the south, and had been altered by fill or soils that had been graded. Several invasive species flourished there, including lespedeza (*Lespedeza cuneata*), Japanese stiltgrass (*Microstegium vimineum*), Japanese honeysuckle (*Lonicera japonica*), and multiflora rose (*Rosa multiflora*).

Prince William Forest Park resource management staff worked with Dave Steensen of the NPS Geologic Resources Division to prepare an implementation plan for the reclamation of this land in 2004. This plan involved assessing the site and developing a task list of needed reclamation work. Planning also entailed conducting cross-sectional volumetric surveys to map the geometric shape of a swale that would reconstruct the natural topography of the site, using adjacent topography and existing drainages to guide the design. The contract for the work was awarded at the end of 2004. Before these plans could be implemented, park staff and volunteers removed more than 3,000 tires and several hundred pounds of trash;

Volunteers assist Prince William Forest Park staff in removing tires from the former Thomas tract. Before reclamation, parts of this tract had been used as a dump.

All trash, buildings, and concrete and asphalt rubble were removed and a swale was constructed to restore historical drainage. The project also included treating invasive vegetation and planting native grasses and trees. This photo shows the Bradford tract after reclamation.

one well was capped; one remaining structure was removed, which included asbestos abatement; and nonnative plants were treated.

Initial reclamation was completed in the summer of 2005 and included removal of more trash, concrete, asphalt, and all remaining structures; regrading the terrain; and restoring historical drainages by creating the swale with approximately 5,000 cubic yards (3,825 cu m) of compatible material obtained from a local construction site. Staff planted native grasses and 120 native trees, including red maple (*Acer rubrum*), river birch (*Nigra betula*), tulip poplar (*Liriodendron tulipifera*), sycamore (*Platanus occidentalis*), pin oak (*Quercus palustris*), and sassafras (*Sassafras albidum*).

Over the next five years, permanent photo points will be used to monitor the progress of the reclamation efforts, and interpretive information will be developed highlighting the success of the project and the need for disturbed-lands restoration. These areas will never be pristine, but as a result of this reclamation, natural hydrology and native vegetation with accompanying animal life are returning. ■

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# Fort McHenry and partners restore wetlands and invite the public

*By Greg McGuire*

**THE WETLANDS ADJACENT TO FORT MCHENRY** National Monument and Historic Shrine (Maryland), where major restoration efforts were initiated in 1997, continue to evolve with the assistance of the National Aquarium in Baltimore and the Maryland State Port Administration. In 2004 the State of Maryland spent $250,000 to improve the hydrology of the area, resulting in a dramatic increase in plant and animal life.

The project involved cutting three inlets through the existing riprap and constructing a network of tidal channels in the marsh to promote regular, natural tidal flooding. The National Aquarium in Baltimore and the Maryland Port Administration cooperated in developing the design with assistance from the National Park Service. The reconstruction was needed because three small culverts, built in the 1980s, had filled with silt, largely cutting off tidal exchange and resulting in several deleterious effects to the wetland. Primary among these were invasion and colonization by common reed, *Phragmites australis*. The clogged culverts also prevented the juveniles of migratory fish species, including striped bass, perch, and herring, from using the site as nursery habitat. After reconstruction, the aquarium and volunteers planted more than 50,000 native plants throughout the site. More recently the state has followed up by removing the phragmites.

*[Improving the hydrology of the marsh] involved cutting three inlets through the existing riprap and constructing a network of tidal channels … to promote regular, natural tidal flooding.*

Many educational programs now take place on and around the marsh. Aquarium staff developed the AquaPartners program with Baltimore City Elementary Schools. Staff conducts nature walks with schoolchildren, teaching them about marsh ecology, the importance of wetlands, effects of stormwater pollution, and other environmental issues. In another program the aquarium partners with the Maryland Sea Grant to raise striped bass at local schools and release them in the wetlands at the end of the school year. The aquarium also maintains a demonstration aquaculture system adjacent to the wetland to raise striped bass. Fort McHenry provides a tour of the historic Star Fort for school groups. Over the past three years of the program, more than 3,300 students from 11 city schools have visited the park.

Members of the Baltimore Bird Club monitor bird populations and migration patterns daily and have observed 234 species, including bald eagle and rarities such as western kingbird, ash-throated flycatcher, and Asian black-throated gull. This

bird list represents a remarkable 55% of all bird species observed in the state of Maryland. White-tailed deer, beaver, muskrat, and a breeding pair of red fox have also been seen at the site.

An advanced, automated system, the YSI 6600 data logger, monitors water quality. Every 15 minutes this instrument measures dissolved oxygen, salinity, temperature, turbidity, pH, and chlorophyll at a site just west of the wetland. The aquarium partners with the Maryland Department of Natural Resources (DNR) on this project. The monitoring data are later displayed on the DNR's Web site.

This year Fort McHenry was awarded a $25,450 grant from the National Park Foundation through the Unilever Recycling at Work Program to construct two pedestrian footbridges in the wetlands to traverse the open canals. This will enable the national park to provide additional educational programs and species monitoring of the area. Expanding access to the site will allow additional groups to study, understand, and enjoy the natural resources flourishing here as the salt marsh is restored. ■

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With the assistance of the National Aquarium in Baltimore and the Maryland State Port Administration, the Fort McHenry tidal wetlands were reconstructed in 2004 (shown before restoration, left) to improve hydrology and eradicate phragmites, an invasive reed, resulting in a dramatic increase in native plant and animal life (shown after restoration, right). Since 1997, park staff has worked with partners and volunteers on quarterly cleanups to remove trash and debris. Educational programs provide opportunities for schoolchildren to learn about marsh ecology, pollution, and other environmental issues.

# 6 Science Education, Outreach, and Citizen Involvement

National parks enjoy great public support and admiration, yet they can play an even greater and more meaningful role in the lives of Americans. One need is to expand the reach and relevance of national parks so that broader segments

of society can enjoy the outstanding values they offer. Moreover, engaging the public in exciting and motivating ways not only helps them form personal connections with the parks but also raises their awareness and appreciation of park purposes and stewardship. Science education and public involvement in the scientific resource management activities of the National Park Service are two important areas that address this need. This chapter discusses a variety of innovative programs developed by the National Park Service and its partners for the public to learn about their national parks in the context of science and to participate directly in their care. Techniques vary from integrating principles of biology and physical sciences exemplified in the national parks into school curriculums to designing park management projects that give participants—often volunteers or students—practical experience in resource restoration or data collection for resource inventory and monitoring. Some of the activities described herein reach out to new audiences; all extend opportunities for the public to establish or deepen their relationships with parks and develop a more sophisticated knowledge of park resources and their management. The results are stimulating, both for park managers who work to preserve national park values on a daily basis and for the public who ultimately decides their fate.

> *"Parks generate passion for learning, with deep, personal, emotional connections born out of experience, and stimulate the curiosity that is the bedrock of science."* — **Gary E. Davis, David M. Graber, and Steven A. Acker**

# Native American science students study camas lily at Nez Perce's Weippe Prairie

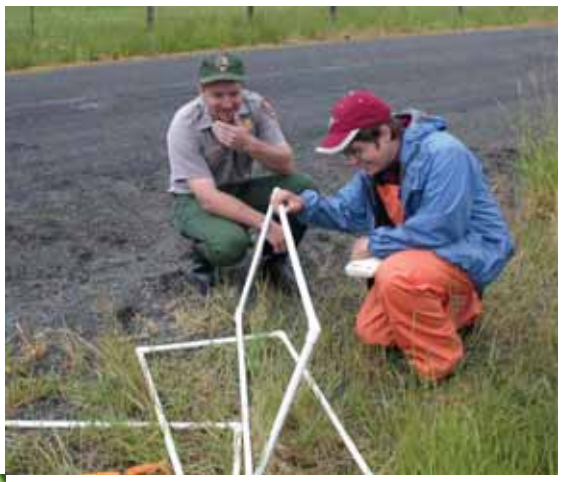
*By Tom Rodhouse*

**NATIVE AMERICAN HIGH SCHOOL SCIENCE STUDENTS** participating in the Oregon Museum of Science and Industry's Salmon Camp program visited the Nez Perce National Historical Park in June 2005 to survey camas lily (*Camassiah quamash*), a plant of both cultural and ecological importance. The park is part of the Upper Columbia Basin Network, and together with the network's Inventory and Monitoring Program, has identified camas as a key park resource and high-priority vital sign, or indicator of ecosystem health, for long-term monitoring.

Camas, an ecologically significant wetland species, is historically one of the most widely used root crops of the Nez Perce people, and remains so for many tribal members today. It is also a focal resource at many historical events memorialized by the park. In September 1805, during the camas harvest at Weippe Prairie, located near Lewiston, Idaho, the Lewis and Clark Corps of Discovery first encountered the Nez Perce. The Corps had just completed the grueling journey over the Bitterroot Mountains and were out of food and exhausted. The Nez Perce fed them camas, among other foods, and many historians believe that the expedition would have failed without this assistance. Camas is therefore a central element of the cultural landscapes that the park seeks to interpret for the public, and its status as a focal cultural resource is one of the rationales for establishing a camas monitoring program.

Salmon Camp is a National Science Foundation–supported program designed to introduce Native American students to natural resource careers through the unifying theme of Pacific Northwest salmon conservation and recovery. Camas, like salmon, is also a culturally significant natural resource in decline throughout the region. In a natural extension to the salmon theme, students engaged in a "camas camp" and spent three days at the park site working with network and park resource staffs surveying camas and the invasive species sulphur cinquefoil (*Potentilla recta*). Park interpretive staff introduced the students to the cultural history of the site. Three student teams, each led by National Park Service staff, visited a set of sampling plots along a preestablished grid of transects and measured stem density and frequency of the two target plant species. They collected data that were stored in handheld computers (PDAs) with GPS and specialized GIS mapping software provided to the network by the Rocky Mountain Cooperative Ecosystem Studies Unit. The group spent their final afternoon together compiling and reviewing results, and discussed the significance of their findings for site management and long-term monitoring.

Altogether the teams completed measurements at 177 plots along 16 transects. Preliminary results suggest a negative correlation between camas and sulphur cinquefoil, in which camas is more frequent and abundant in areas with less cinquefoil. This is encouraging



Nez Perce National Historical Park resource manager Jason Lyon helps a Salmon Camp student assemble sampling frames for use by Native American science students in the camas field surveys. Camas (below) is a significant cultural and ecological resource at the park, where it has been selected for long-term monitoring as a vital sign, or indicator of park ecological health.

Salmon Camp students look for camas and sulphur cinquefoil inside a 5.4-square-foot (0.5-$m^2$) sampling frame. Over two days they measured stem density and frequency of the two plant species at 177 plots.

news to the park resource staff, who is conducting an active invasive species control program at the site. Encouraging results were also obtained from a preliminary calculation of required sample size for detecting change in the frequency of these plant species over time. If these data are representative of the entire site over subsequent years, it appears likely that a cost-effective and efficient camas monitoring program can be conducted at the site. A monitoring program will provide park resource staff with a direct measure of the camas population in addition to that of threatening invasive weeds.

The Upper Columbia Basin Network is focused on developing a camas monitoring protocol that will accommodate citizen scientists such as Salmon Camp students and others like them. As a means of stretching limited dollars and providing state-of-the-art science education, the network hopes to develop citizen science components of several of its monitoring efforts. The experience of the 2005 Salmon Camp program at Weippe Prairie clearly demonstrates that with proper training, clearly defined objectives, and detailed protocols, this can be done. The network plans to test a fully developed monitoring protocol for camas with Salmon Camp students at Weippe Prairie again in 2006. ■

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# Successful partnership with The Nature Conservancy fosters corps of volunteers to tackle nonnative plants in Potomac Gorge

*By Mary Travaglini*

**EACH YEAR THE EXOTIC PLANT MANAGEMENT TEAMS** (EPMTs) of the National Park Service tackle thousands of acres of invasive nonnative plants threatening natural resources around the country. The expanding problem with nonnative plants in the national parks, though, is beyond what these teams alone can manage. Through a partnership among two national parks, the National Capital Region Center for Urban Ecology, and The Nature Conservancy, volunteers from local communities in Washington, DC, Maryland, and northern Virginia have been mobilized to respond to the problem. They contributed more than 2,000 hours of service in 2005 to control invasive nonnative plants in the Potomac Gorge, a 15-mile (24 km) river corridor that includes parts of two national parks: the George Washington Memorial Parkway and Chesapeake and Ohio Canal National Historical Park.

*Weed Warrior and Weed Buster volunteers have assisted the National Park Service in the control of 19 invasive plant species.*

The Potomac Gorge, a 9,700-acre (3,929 ha) conservation area in Maryland, Virginia, and the District of Columbia, is one of the most biologically significant natural areas in the eastern United States, with occurrences of 134 rare plant species and five globally rare plant communities. Yet, more than 130 nonnative invasive plants threaten the diversity of life in this short stretch of river valley.

Invasive nonnative plants have been identified by the National Park Service, The Nature Conservancy, and the States of Maryland and Virginia Natural Heritage Programs as one of the greatest threats to rare plants and communities in the Potomac Gorge. Through a Cooperative Conservation Initiative grant from the National Park Service and matching funds from The Nature Conservancy and other partners, The Nature Conservancy has enlisted more than 300 volunteers in a series of supervised "Weed Buster" volunteer workdays and trained 30 volunteers as "Weed Warriors" to combat nonnative plants in the gorge.

Volunteers in Parks (VIPs) have been invaluable in helping the National Park Service accomplish numerous essential activities, but volunteers are often ephemeral or lack the training to do delicate resource protection tasks. The Nature Conservancy assisted the National Park Service by developing a 10-hour training for Weed Warriors so that they can confidently, professionally, and independently control nonnative plants on NPS lands in the Potomac Gorge. The training details the identification and mechanical control methods of 13 nonnative plants, protection of park resources, park visitor education, safety, and emergency management. After an introduction to their adopted area, Weed Warriors head out as NPS VIPs, armed with orange vests, clippers, and saws, and work whenever it best suits their schedules. After each visit, they return an "action report," including details on what plants they treated, treatment methods used, interactions with visitors, and plans to return.

In addition to the successful Weed Warrior program, The Nature Conservancy has worked with both park units in the gorge to organize

The Potomac Gorge, a 15-mile (24 km) river corridor near the nation's capital, has one of the highest concentrations of rare plant species in the nation. Two plant communities here are found nowhere else in the world. One of the greatest threats to this biodiversity is invasion by nonnative plants.

Citizen volunteers aid the National Park Service in controlling exotic vegetation, such as this linden viburnum (*Viburnum dilatatum*) in the Potomac Gorge. This shrub species has spread rapidly through acres of upland forest in Turkey Run Park, and volunteers like Margaret Chatham have dedicated hours of their personal time to help control its spread.

and supervise Weed Buster volunteer workdays to control nonnative plants. Volunteers may participate on these group workdays without prior experience and receive training on the job. Nature Conservancy staff has special training and permission to apply herbicides as needed for woody species cut during the workdays, complementing the manual control work of the volunteers.

As a result of these initiatives, Weed Warrior and Weed Buster volunteers have assisted the National Park Service in the control of 19 nonnative plant species, treating approximately 20 acres (8 ha) of habitat in the Potomac Gorge primarily through mechanical control, often in areas that are difficult to access. Weed Warriors become intimately familiar with their adopted area and provide feedback on the success of control efforts. Alongside the efforts of the National Capital Region EPMT, they have become invaluable in stemming the tide of nonnative plants and strengthening the partnership between the George Washington Memorial Parkway and the C&O Canal National Historical Park to protect biodiversity in the Potomac Gorge. ■

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# Multipark program teaches students how to appreciate their rare, fragile backyard

*By Bruce Izmirian*

**SOUTHERN CALIFORNIA** is home to more than 17 million people and has an abundance of some of the most diverse plant and animal species found anywhere in the world. Yet many of those who live and recreate in the area lack an awareness of the rare and fragile ecosystem (classified as "Mediterranean") that is their backyard. This lack of knowledge can make park management more difficult when issues involving research are interpreted to a public that may not understand, or care about, the significance of the research findings.

A citizen science education program called Each One, Teach One is helping remedy this problem. From June 2004 to July 2005, the program helped promote research occurring in three national parks in southern California. Funded by the California Mediterranean Research Learning Center, this program helped scientists from Santa Monica Mountains National Recreation Area, Cabrillo National Monument, and Channel Islands National Park share current research data with a core group of three college interns in a one-week intensive training period. The purpose of the research learning center is to establish a cooperative management, research, and education effort that supports research in the three parks' ecosystems. It seeks to involve and educate the public in park research through citizen science opportunities.

*This program … helped close the gap between scientists and students … [and] stands as a template of what successful research learning center programs can achieve.*

Research overviews included world and local Mediterranean ecosystems, wildland fire, vegetation, marine ecosystems, wildlife, and cultural history. Each park was assigned supervision duties for one project intern. After the one-week training, interns continued to gain specialized knowledge while working closely with resource management and education staffs at their assigned park.

According to teachers, "average" students had had few opportunities before the program to demonstrate their knowledge and understanding of local ecosystems. Each One, Teach One provided the forum in which students applied and demonstrated what they learned about the scientific method, National Park Service science, and ecosystem preservation. The information gained from this training then empowered the interns to become teachers. Interns shared their knowledge by developing and presenting curriculum-based lessons for Los Angeles, Ventura, and San Diego County high school science classes. They facilitated in-park service learning studies focusing on fundamental concepts about research components and ecosystem challenges. They also shared their expertise with other students and the public through production of an educational video and traveling exhibit.

The response from both teachers and students was extremely positive. Teachers agreed that the program went beyond their expectations in meeting curriculum objectives. Excited about continuing this hands-on program, teachers said that it expanded their students' world, teaching them about the unique ecosystem that is their own backyard. Students agreed that they were more informed about their Mediterranean ecosystem and more concerned about taking care of it. They urged the National Park Service to keep the program going in order to help more students understand the importance of preservation.

Increased public support for NPS efforts in the scientific, education, and preservation fields emerged as a major benefit of this cooperative project. One hundred seventy-nine students and 7,200 park visitors established a foundation on which to base future growth and urban planning decisions in a holistic and scientifically based way. Marketing of the project video for broadcast through community and educational television stations was scheduled for January 2006. Video outreach is guaranteed to exceed the life and funding for the program and requires minimal staff assistance while reaching large audiences.

The project also created preservice training opportunities for student participants. Two undergraduate project interns are currently working for the National Park Service in seasonal and research capacities. Several high school students have expressed a desire to conduct more in-depth work as park interns.

This program, which developed in response to a call for network projects supporting research learning center goals, helped close the gap between scientists and students. It stands as a template of what successful research learning center programs can achieve.

Each One, Teach One helped connect students, teachers, and the general public with the resource. Understanding frequently brings appreciation, and appreciation brings caring and protection. As keepers of America's treasures, the National Park Service is providing a hands-on opportunity for students to learn about their natural and cultural heritage. This program is also building future stewards of a rare and fragile biome that belongs to all. ■

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Debbie Kiner, education volunteer at Santa Monica Mountains National Recreation Area (left), and Pacifica High School students conduct vegetation studies on Santa Cruz Island for the Each One, Teach One science education training program. This program, funded by the California Mediterranean Research Learning Center, highlighted how educating and mentoring students, who then become teachers themselves, on important ecological issues can enhance the management of national park units.

Barbara Collins, student intern at Channel Islands National Park (left), and Pacifica High School students study animal tracks on Santa Cruz Island. Scientists from Santa Monica Mountains National Recreation Area, Cabrillo National Monument, and Channel Islands National Park shared current research data with a core group of college interns in a one-week intensive training program. All participants were engaged in an enhanced awareness and understanding of the complexity of natural resource management.

# LaQuincy Arnold, ambassador for national park conservation

*By Gillian Bowser*

**LAQUINCY ARNOLD**, a junior at Prairie View A&M University in southeastern Texas, is part of the next generation of conservation leaders and is also a talented student and an outspoken supporter of the National Park Service and several of its conservation partners. He gained interest in the Park Service and its conservation mission in 2004 when he accepted a summer internship at Big Thicket National Preserve, 40 miles (64 km) south of Kountze, Texas, where he grew up. Sponsored by the Student Conservation Association (SCA) and working under the leadership of Acting Chief of Interpretation Leslie Dubey, LaQuincy, who goes by "Quincy," was involved with a variety of park projects under several divisions, including Interpretive Education, Natural Resource Management, Fire, Maintenance, and Administration. This SCA resource assistant position gave him his first exposure to natural resource management issues. Though he worked primarily on interpretation programs, introducing young people to park natural resources, he also participated on fire and hog management crews and helped maintain park trails.

*Quincy is a young and devoted ambassador for the National Park Service and actively shares his work experiences with his peers at Prairie View and other historically black colleges.*

The following semester, Quincy came to Texas A&M University as a student intern through Prairie View's cooperative education program, where he was part of the unique partnership of Texas A&M and the Gulf Coast Cooperative Ecosystem Studies Unit (CESU). In that role he worked directly with Robert Stanton, former NPS director and senior fellow at the university, and Dr. Gillian Bowser, CESU research coordinator and National Park Service liaison, coordinating the Distinguished Lecture Series, arranging field trips to several units of the National Park System, and conducting a literature review on minority issues within Fortune 500 companies and on these companies' commitment to professional development. He was particularly engaged in this project because he feels strongly about diversity in the workplace and believes that many organizations do not recognize the value of a diverse workforce. In addition, his research enhanced the issues highlighted by Mr. Stanton in his lecture series on parks and environmental justice.

Quincy is a young and devoted ambassador for the National Park Service and actively shares his work experiences with his peers at Prairie View and other historically black colleges. In fact he has personally recruited students to work at the Gulf Coast CESU in cooperative education positions; two of those students went on to work at national parks in 2005 and will be returning for another summer season in 2006. He hopes that by sharing his recent work experiences, he will be able to ignite the interest of other minority students in careers in conservation and the National Park Service.

LaQuincy Arnold holds leadership positions in some of the most respected organizations on the campus of Prairie View A&M University, where he is a junior. His work with the National Park Service demonstrates the value of the Student Conservation Association and Texas A&M University, the host university of the Gulf Coast Cooperative Park Ecosystem Studies Unit, in exposing promising minority students to careers in conservation and with the National Park Service.

Quincy will continue his professional development with the Park Service in 2006 by working on the business plan for National Capital Parks–East in Washington, DC. He will be the only undergraduate on a team of graduate students from leading business schools in the nation. In developing a business plan for the park, the park staff will have compelling supportive documentation for their financial and programmatic decisions, a substantive resource for setting priorities and implementing management strategies, and increased credibility with internal and external stakeholders. Quincy was introduced to the NPS business plan concept in the summer of 2005 while working in the SCA regional office in Arlington, Virginia. There, Senior Vice President Flip Hagood served not only as his supervisor but also as a mentor and role model. Quincy worked with the SCA team to coordinate the annual training session for the Business Planning Initiative held in Yosemite National Park, and attended that training to begin his work with National Capital Parks–East. He is continuing to develop the business plan through the spring 2006 semester based at Texas A&M, then will join the staff of the park and work under the leadership of Superintendent Gayle Hazelwood.

Quincy continues his close relationship with Robert Stanton and Gayle Hazelwood, who have mentored him over the last year and are watching him mature into a true leader. "I have a great deal of respect for the phenomenal mentors and giants in conservation that I have had the privilege of meeting," Quincy says. "Robert Stanton, Gillian Bowser, Flip Hagood, Gayle Hazelwood, and Leslie Dubey all have been so influential throughout my work experience with the parks." Quincy is grateful for nonprofit organizations, such as the Student Conservation Association, that provide students with experience and a strong and supportive network that is tremendously beneficial to the success of their careers. He appreciates the opportunities he has had to develop professional skills related to the conservation of national parks and finds them inspiring as he continues his educational development. Quincy is a business management major with a minor in English and has plans to attend law school after completing his undergraduate studies at Prairie View. ■

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# "Bridges" helps teachers improve science education in California classrooms

*By Debbie Savage*

**REDWOOD NATIONAL AND STATE PARKS** has a secret strategy for encouraging California students to consider careers in science: giving students tangible tools, engaging experiences, and relevant activities that include all learning styles. Bridging the gap between the classroom and future science careers is the goal of "Bridges," a comprehensive curriculum that connects state and national science education standards with the primary interpretive themes of Redwood National and State Parks. The curriculum allows students to explore resource management methods through hands-on activities. Most classes are not able to travel to the parks, so the staff decided to take the parks to the students. In 2005, park staff completed the curriculum for seventh and eighth graders, which has received an enthusiastic response from both students and teachers.

The curriculum focuses on park animal species that offer a signal of biological changes in the ecosystem, known as indicator species. Northern California steelhead (*Oncorhynchus mykiss*), marbled murrelet (*Brachyramphus marmoratus*), mountain lion (*Puma concolor*), and Roosevelt elk (*Cervus elaphus* subsp. *roosevelti*) allow students to explore the mosaic of habitats within the parks and region. Students discuss how scientists learn about wildlife and their habitats in order to monitor, enhance, and restore them. Because the focus is on investigating resource management techniques, students learn about radio tagging, stream pebble counts, and animal-sighting logs. They also learn how data influence resource management decisions. Park scientists and interpretation staff designed all of the activities in the curriculum in consultation with teachers from the local community. Activities and educational concepts were tested at workshops and in the classroom.

*The [teacher's] guide has 11 units that explore research methods used by the parks' resource managers and how this research helps determine management decisions and practices.*

The materials include a 115-page teacher's guide and a wheeled resource trunk containing all the necessary supplies for conducting the activities outlined in the curriculum. The guide has 11 units that explore research methods used by the parks' resource managers and how this research helps determine park management decisions and practices. Six trunks are available for teachers to check out through the school district media centers in Del Norte and Humboldt Counties. The materials include conventional teaching aids like videotapes, books on the redwood ecosystem, and field guides to animal tracks and stream organisms. The trunks also contain unexpected materials, such as animal track and scat replicas, elk and mountain lion skull and tooth replicas, and a copy of a marbled murrelet egg. What seventh or eighth grader would not get excited about scat?

Looking for an innovative way to interest students in science, interpretation staff at Redwood National and State Parks developed a comprehensive resource management curriculum for teachers to present to their seventh and eighth grade students. All of the activities were created in consultation with teachers from the local community and tested at workshops and in the classroom, where they received an enthusiastic response.

Teachers found the trunks very useful too. "The contents of this trunk were interesting, well thought out, and very appropriate to our area. [The curriculum] was both fun and educational, plus it could be used by many different grade levels," noted Castle Rock Charter School teacher Margie Rouge.

The Bridges curriculum also features activity sheets. Called "Redwood Log" student pages, the sheets provide information, graphs, and charts for students to organize data, and space to record observations. As the activities are completed, students can gather the pages into a personal folder or logbook to serve as a learning assessment tool.

The critical need for innovative solutions to increasing the participation of young people in science is evident in the range of organizations that provided financial support for the project: Exxon Mobil Corporation, Save-the-Redwoods League, National Park Foundation, Parks as Classrooms, and Redwood Park Association.

The Bridges project has introduced local students to the distinct natural history of Redwood National and State Parks. It has also helped build understanding of the importance of a stewardship ethic in protecting the natural environment. Students have learned that science can be relevant and enjoyable, perhaps sparking a lifelong interest in science for some participants. Park staff is also hopeful that one or two of the students will return in the future as park scientists. After all, this project is all about the future. ■

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# Volunteers collect dragonfly cast skins for survey along Potomac River

*By Richard Orr*

Volunteers helped inventory dragonflies and damselflies in a survey along the Potomac River by collecting the skins discarded when larvae become adults. This newly emerged black-shoulder spinyleg dragonfly rests on top of its cast skin at Chesapeake and Ohio Canal National Historical Park.

**IMAGINE GROWING BY SPLITTING YOUR SKIN** and walking away from the dried husk. Dragonflies grow this way; the skins that are left behind are called "cast skins," which can often be identified to species. From 2002 to 2004 the National Capital Region of the National Park Service conducted a detailed survey that made use of the cast skins of dragonflies and damselflies of the Potomac River and its adjacent wetlands at Harpers Ferry National Historical Park (West Virginia and Virginia), Chesapeake and Ohio Canal National Historical Park (Maryland and District of Columbia), and the George Washington Memorial Parkway (Virginia). The goal of the survey was to find out which species were present and which might be at risk because of mosquito management for West Nile virus. The parks were considering spraying an insecticide to control mosquitoes and needed to understand the effects this action would have on other species of insects.

The Potomac River is large and difficult to sample for aquatic insects. Many microhabitats in the river support different insect assemblages. These areas are not obvious when viewed from the shore or surface, making surveys expensive and sometimes dangerous. Fortunately, dragonfly larvae from all parts of the river ultimately end up leaving their cast skins along the shore when the adults emerge. Experts can then examine the skins and determine which species are living there. Damselfly cast skins were also collected occasionally, but they are better surveyed by other techniques.

The National Capital Region contracted Versar, Inc., to coordinate the survey, with volunteers providing the many hours of labor along the river. Though they have rarely been used for detailed scientific surveys targeting aquatic insects, these citizen scientists were essential for this study, which would not have been possible without their help and dedication.

*Over … three field seasons, 23 volunteers worked 160 field days, contributing 552 volunteer hours … and collecting more than 4,000 cast skins from which 3,347 were identified to species.*

Versar, an environmental consulting company, along with the Audubon Naturalist Society and Partners in Parks, coordinated a workshop early in 2003 to train the NPS volunteers in making the collections and worked out the related program logistics. Over the next three field seasons, 23 volunteers worked 160 field days, contributing 552 volunteer hours to the project and collecting more than 4,000 cast skins from which 3,347 were identified to species.

Park managers were amazed at the number of dragonflies the volunteers collected. In total, 101 species of dragonflies and damselflies were identified from the cast skins. Forty-five of the species are of conservation importance because they are rare in the District of Columbia, West Virginia, Maryland, and Virginia. Many of the records of the rarest dragonflies came from cast skins found by the volunteers.

No immediate management decisions about controlling West Nile virus emerged from this study because the threat of the virus seems to be in abeyance, possibly because the dragonflies themselves are doing such a good job of controlling the mosquitoes. However, data gained from this survey will inform future management decisions when control of mosquitoes or other problem species is called for now that managers know that some of the 101 species of dragonflies and damselflies might be affected. ■

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# Maintaining the integrity of native plant communities in Glacier Bay

*By Whitney Rapp*

**SPECIES LIKE COMMON DANDELION** (*Taraxacum officinale* subsp. *officinale*), red and white clover (*Trifolium pratense* and *T. repens*), and annual bluegrass (*Poa annua*) are ubiquitous across America, just like fast-food restaurants and big-box stores. Unfortunately, these plants are not native to the United States and negatively affect native biota. In remote Alaska, including Gustavus, the gateway to Glacier Bay National Park and Preserve, nonnative vegetation is also establishing itself. The nearest grocery store or fast-food restaurant is a 60-mile (97 km) flight or boat trip away, but aggressive, nonnative plants have made the trip to the wilderness. The distinct and unspoiled quality of Glacier Bay is now in jeopardy from nonnative, or exotic, plants. In 2005, during the first year of a local effort, the invasive plants program surveyed more than 500 acres (203 ha), removed 3,300 pounds (1,500 kg) of nonnative plants, and initiated community outreach and education efforts.

Nonnative plant invasions generally begin in areas of human disturbance, including roadsides, vacant lots, and campgrounds. While only the developed area of Glacier Bay has substantial human disturbance, natural disturbances are common throughout the park and leave it vulnerable to colonization by nonnative species. Consider that two centuries ago glaciers covered the majority of the park now enjoyed by visitors each year. As the glaciers retreat, newly exposed ground is extremely susceptible to invasion by opportunistic plants. One of Glacier Bay's founding missions is to serve as a natural laboratory for studying postglacial plant succession, but this process is dramatically altered with the arrival of nonnative species.

In 2005, the first year of a local invasive plants program in Glacier Bay, nearly 500 acres (203 ha) were surveyed using the protocols of the Alaska Region Exotic Plant Management Team (EPMT). Since the park is the size of the state of Connecticut (3.3 million acres; 1.3 million ha), most of the effort focused on the coastal areas most used by visitors. Twelve new nonnative species were identified, bringing the total nonnative plant species to

Children in Gustavus, Alaska, show their faces painted with native flowers during a public event celebrating the native flora of the area. Several outreach events have targeted the youth of the community in hopes that they will take the message home to their families and their yards.

37. Of these, only 5 have invaded the backcountry. Considering the widespread distribution of nonnative species in other park units, Glacier Bay considers itself fortunate. Accordingly, the park is working proactively through early detection and rapid response to prevent the wilderness landscape from deteriorating and falling prey to the homogenizing influence of aggressive, nonnative plants.

*One of Glacier Bay's founding missions is to serve as a natural laboratory for studying postglacial plant succession, but this process is dramatically altered with the arrival of nonnative species.*

This year, more than 3,300 pounds (1,500 kg) of nonnative plants were pulled or dug in 127 hours by a crew that included one employee and many volunteers. Control efforts focused on the developed areas of the park to limit future dispersal and targeted the most aggressive species, including reed canary grass (*Phalaris arundinacea*), ox-eye daisy (*Leucanthemum vulgare*), timothy (*Phleum pratense*), and dandelions. In the backcountry, control efforts focused on eradicating disjunct infestations. Except for dandelions, park staff anticipates that all other nonnative plants will be removed from the backcountry within a few years.

The invasive plants program has initiated community outreach and education efforts aimed at raising awareness. One event was the "Invasive, Exotic Flower Arranging Contest," which was held during the Fourth of July celebration, Gustavus's largest annual gathering. The colorful and creative floral arrangements drew attention to the display where people could learn about exotic species. What could be more patriotic on Independence Day than working to protect our native species? Other outreach events have targeted the youth of the community in hopes that they will take the message home to their families and their yards.

In 2005 the program was supported by funds from three National Park Service sources: the Alaska Region EPMT, the Southeast Alaska Coastal Cluster, and Glacier Bay National Park and Preserve. With continued vigilance and appropriate allocation of resources for inventory, control, and education, the invasive plants program aims to maintain the integrity of Glacier Bay's native ecosystems. ■

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Nonnative plants, including ox-eye daisies, large-leaved lupines, and hawkweed, are arranged on a bike for the "Invasive, Exotic Flower Arranging Contest." Through fun and innovative events like this one, Glacier Bay National Park and Preserve is educating the community about the effects nonnative plant species can have on native ecosystems.

Nonnative common dandelions grow alongside native plants in a meadow at Glacier Bay National Park and Preserve. The same nonnative plants that are displacing the native flora elsewhere in the United States are altering the distinct and unspoiled quality of Glacier Bay.

# Visitors fascinated by Canaveral National Seashore's Sea Turtle Watch Program

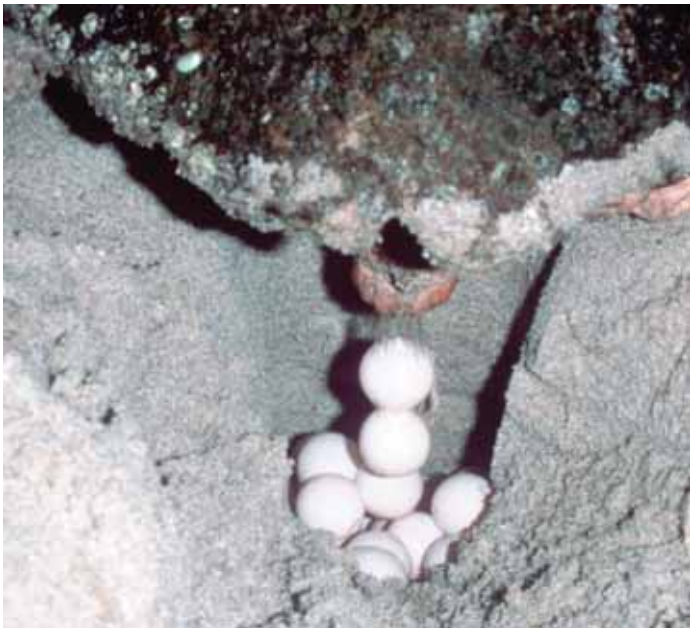
*By Laura E. Henning*

**EACH SUMMER, SEA TURTLES RETURN** to Canaveral National Seashore in Florida to make their nests and lay their eggs, but the turtles are not the only ones drawn here for this event. In June and July 2005, interpreters guided more than 1,600 visitors on nightly walks in a quest to view nesting sea turtles and learn about the national seashore's efforts in sea turtle conservation. Because of its protected status, Canaveral National Seashore is the perfect classroom for observing how sea turtles behave in nature without interference from lights, traffic, or artificial barriers on the beach.

*For visitors this shared experience establishes an emotional connection to a species that many know little or nothing about before they come to Canaveral National Seashore.*

The experience of the turtle watch is as extraordinary as the nesting process itself. It is resource immersion at its finest. The program begins with a hands-on talk about sea turtles and Canaveral National Seashore's role in their preservation. Tension and excitement mount as the group awaits the call that will take them to the dark beach to see the real thing. The group is quietly led to the nesting loggerhead turtle as she is laying her eggs. The rangers and volunteers use red-filtered flashlights to provide a better view without disturbing the female turtle. Though the group may number up to 30, the volunteers are quiet and awestruck. Whispers about her size and the perfectly round Ping-Pong ball–sized eggs mix with comments of appreciation for what she is going through. When she finishes covering her nest and returns to the ocean, the group breaks into a satisfied round of applause. For visitors this shared experience establishes an emotional connection to a species that many know little or nothing about before they come to Canaveral National Seashore.

During summer 2005, the 22nd season of the sea turtle nesting program, the national seashore was the site of 3,600 nests made by green sea turtles (*Chlonia nydas*), leatherbacks (*Demochelys coriacea*), and the threatened loggerheads (*Caretta caretta*). Nest numbers have ranged from 1,776 in 1987 to a high of 4,563 in 2000. Volunteers and biotechnicians put in hundreds of hours on the beach collecting data on nests and screening them from predators. Turtle watchers have been concerned that the number of loggerhead turtle nests has declined in recent years, and data collected over the last five years do show a slight downward trend in 2004 and 2005. In the next few summers, program participants will collect crucial data regarding the future of the threatened loggerhead sea turtles that come to nest at Canaveral National Seashore where they provide an unforgettable experience for visitors. ■



(Above) The endangered green sea turtle may not reach reproductive maturity until 30 years of age. Canaveral National Seashore had a record 1,039 green sea turtle nests in 2005. (Below) This loggerhead sea turtle is depositing her eggs and lays between 80 and 150 per clutch.

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# Education program targets plant restoration at Santa Monica Mountains

*By Jack Gillooly*

**IN THE SANTA MONICA MOUNTAINS** of southern California, a long history of human occupation has left the landscape with a complex variety of natural and disturbed habitats. Native plant communities—coastal sage scrub, chaparral, and oak woodlands—are interspersed with patches and fields of nonnative annual grasses and other invasive species. Erosion can be high and biodiversity low, with little natural recovery of native vegetation. Compounding the problem is the mountain checkerboard of public and private ownership, as backyard plants continue to escape into parklands.

Sounds like a mission for "EcoHelpers," a successful restoration-education program at Santa Monica Mountains National Recreation Area. Each year, 2,000 diverse high school science students from the Los Angeles area are signed on as park volunteers to pull weeds and plant native vegetation during school field trips. For many it is their first visit to a national park, and comes with a crash course in Gardening 101. The students also receive important lessons in watershed ecology, invasive species, and the wildlife benefits of restoration, qualifying them for "service learning" credit needed for graduation.

The EcoHelpers project is a close partnership between the park's Resource Management and Interpretation Divisions. Resource Management oversees the restoration planning, including site prioritization, selecting plant palettes, seed collection, and operating the plant nursery. Interpretation takes care of the education elements and guides the field trips. Both divisions enlist adult volunteers and gather funding for the program's full-time NPS coordinator, equipment, and school buses. The pilot program was funded in 2003 by the California Coastal Commission, with subsequent funding from federal sources: the Cooperative Conservation Initiative, Challenge Cost-Share, and Public Lands Commission.

After clearing weeds and learning how to plant native species, students help restore a national parkland. For years to come, they can return and see the fruits of their volunteer labor.

At the restoration site, EcoHelpers coordinator Eli Dickerson guides student volunteers in proper planting and weeding techniques. Training for the program also includes an ecology talk and guided walk. Students learn to identify nonnative plants, discuss their detrimental effects, and discover how native plants benefit wildlife.

In 2004 and 2005, EcoHelpers focused on degraded streamside habitat in Solstice Canyon, where a dominant new nonnative species was taking over: *Euphorbia terracina*. After eliminating large patches and replanting 3 acres (1.2 ha), the program will move to Zuma Canyon in 2006 for an attack on mustard, Russian thistle, castor bean, and fennel. Along with euphorbia, these plants are high on the park's target list, especially when they cover large areas, as in Zuma.

Beyond the habitat benefits of the program, interns and staff have been testing different restoration strategies. New mulching combinations, aftercare techniques, and planting patterns have improved plant survival and helped minimize weed regrowth. Continuous monitoring keeps track of remaining weed seed banks while long-term recovery is charted in photo points.

EcoHelpers has shaved decades off habitat recovery time and is an effective tool in the park's restoration and education programs. Park staff is happy to share information to help other parks start similar programs. ■

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# Colorado State University graduate students improve awareness of Heartland Network's inventory and monitoring activities

*By Sara Melena, Chris Mayer, Tawnya Ernst, and Cara DiEnno*

**IF A TREE FALLS IN THE FOREST** and no one is there to hear it, does it make a sound? More importantly, is park science really relevant if only a handful of scientists are aware of new findings and can understand their implications for park resources? As park management becomes more complex with many management issues spanning park boundaries, communicating new research findings with park managers, visitors, local residents, and others who might have a hand in effecting change and addressing natural resource challenges becomes increasingly important. The Heartland Network Natural Resource Monitoring Program recognized the need to communicate the results of ongoing monitoring and inventory efforts. In 2005 the network enlisted a team of Colorado State University (CSU) graduate students, under the direction of the Natural Resource Program Center's Office of Education and Outreach, to develop strategies for raising awareness about and understanding of the purpose, objectives, and benefits of the network's inventory and monitoring activities.

*Heartland Network scientists understand that converting data into compelling stories that illustrate the importance of their research is good for both their program and the parks.*

The Heartland Network monitoring program was established as part of the park vital signs monitoring program, which provides park managers with accurate scientific information needed to make sound management decisions about the resources in their care. More than 270 parks with significant natural resources have been organized into 32 networks. Each network conducts long-term monitoring of key indicators of change, or "vital signs." Scientists with the Heartland Network measure the condition of water, air, geologic resources, plants, and animals found within the network's 15 parks.

To improve communication about the value of network parks and new scientific findings, the team of graduate students used research results and examples of adaptive management success stories to create thematic messages and communication products. For example, they developed prairie wildflower seed packets that featured an interpretive message about the negative effects of invasive nonnative plant species. Additionally, radio spots were developed on issues like threatened and endangered species, nonnative plants, and water quality. The short radio announcements were recorded for broadcast on park radio or to be downloaded from the Heartland Network's Web site. One of the spots reminds visitors that they can enjoy many of the same plants and animals encountered by Lewis and Clark during their Corps of Discovery expedition more than 200 years ago, thanks in part to NPS inventory and monitoring activities.

The team also produced a short video presenting a broad picture of the Heartland Network and its monitoring efforts, which was made available to internal and external audiences. It supplied templates for interpretive products that can be tailored to the issues and priorities of individual parks. A training presentation, note cards, a brochure, and an electronic newsletter were also products developed by the team.

Scientists at George Washington Carver National Monument, Missouri, one of the Heartland Network parks, sample macroinvertebrates, which are small organisms consumed by fish and an important component of the food web.

As graduate students well know, academic research is not considered complete until it has been published, thereby contributing to the larger body of knowledge. Heartland Network scientists understand that converting data into compelling stories that illustrate the importance of their research is good for both their program and the parks. National Park Service scientists also recognize that they have an obligation to provide the American public with useful scientific information. For these reasons, the Heartland Network is expanding its efforts to communicate to a wider audience. Public outreach is emerging as the final step in the research process for good reason: it benefits the national parks and the people who enjoy them. ■


In 2005 the Heartland Network enlisted a team of Colorado State University graduate students to develop strategies for raising awareness and understanding of the purpose, objectives, and benefits of inventory and monitoring activities. The team developed a range of interpretive products.

Scientists with the Heartland Network measure the condition of water, air, geologic resources, plants, and animals found within the network's 15 parks, including Pipestone National Monument, Minnesota. The national monument supports more than 500 native plant species, including the threatened western prairie fringed orchid (*Platanthera praeclara*), which is regularly monitored.

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# Putting educational materials about parks in the hands of science teachers

*By Bruce Nash and Jim Wood*

**TWO OFFICES OF THE NATURAL RESOURCE PROGRAM** Center in Lakewood, Colorado, have developed digital education materials that support teachers and inform the public about scientific concepts illustrated in national parks. Collaboration between the Geologic Resources Division (GRD) and the Office of Education and Outreach (OEO) has resulted in original, park-focused materials that allow teachers to bring the National Park System into their classrooms. As one user explains, "Each park has its own distinctive features, and when you use science to help explain the features, it makes them even more interesting."

In 2005 the Office of Education and Outreach expanded a program called "Views of the National Parks" through components called "virtual experiences" and "knowledge centers" about wilderness, Grand Canyon–Parashant National Monument, Whiskeytown National Recreation Area, geology of the National Mall, coastal geology, and Tonto National Monument. To broaden the educational opportunities, Views of the National Parks offers multicultural perspectives and examples of how parks have inspired artists, musicians,

*The Natural Resource Program Center … [has] developed digital education materials that support teachers and inform the public about scientific concepts illustrated in national parks.*

and writers, using interactive graphics, 360-degree panoramas, natural sound recordings, and digital movies to stimulate interest in national parks and encourage users to extend their exploration. Developers organized the program around two components: virtual experiences take users on a journey of adventure to a single park, and knowledge centers present information on topics that reach across many parks. In addition to working with subject-matter experts at the Natural Resource Program Center, OEO staff worked with a "master teacher" who wrote and evaluated modules and activities, including lesson plans about wildlife in Grand Canyon National Park, Florissant Fossil Beds National Monument, volcanism, wilderness, and coastal geology. During this collaboration they also developed a teacher resource center that provides suggestions on effectively using the program and links to national teaching standards, lesson plans, activities, and other educational resources.

In partnership with the US Geological Survey (USGS) and local science teachers, the Geologic Resources Division developed a teacher resource site in 2005 to provide educational resources for teaching geology with examples from national parks; the site is extensively linked to Views of the National Parks. The Geologic Resources Division asked volunteer educators to comb through NPS Web pages to evaluate educational materials that park staffs had posted. These

volunteers rated the best sites for Earth science education and posted them on a "jumpsite," which serves as a starting point for teachers and students to probe the labyrinth of NPS pages. Through collaboration with the USGS in Menlo Park, California, GRD staff set up extensive linkages between the NPS and USGS sites, including hundreds of sites about geology in the National Park System and thousands of geologic photos. Over the past year the USGS has greatly expanded its image collection of national parks, including many 3-D images, which users can access via the jumpsite.

The GRD Web pages are available at http://www2.nature.nps.gov/geology/education/index.cfm; Views of the National Parks is available on CD and at http://www2.nature.nps.gov/views/. In 2005 many individuals and organizations came to recognize the usefulness of these materials. For instance, SciMaTEC, an education center at the University of Toledo, Ohio, requested 400 Views CDs for distribution at its Northwest Ohio Symposium on Science, Mathematics, and Technology. One physics teacher who received the CD remarked that national parks help stimulate discussion: "We could talk about the physics of geysers in Yellowstone or the way lava flows in the Hawaiian lava fields. Students are interested in these kinds of things, and when you can relate science [to these features], it just is an added bonus." In addition the Digital Library for Earth Systems Education—a community Web site for educators, students, and scientists working together to improve Earth science education—posted four knowledge centers (volcanism, coastal geology, caves and karst, and glaciers) at http://www.dlese.org. This library is another venue for getting scientific information about national parks into the hands of teachers. It appears to be one of the hottest Internet sites for Earth science teachers and is broadly recognized as a good source of information and materials for natural science education. Also in 2005, WGBH Television in Boston selected portions of these four geologic knowledge centers to be posted on its Teachers' Domain Web site, a National Science Foundation–funded project that uses video, interactive features, primary documents, still photographs, and lesson plans to teach science under national and state K–12 standards. When these knowledge centers go live on the WGBH site in 2006, they will be another avenue for teachers to gather science-related information about national parks. ■

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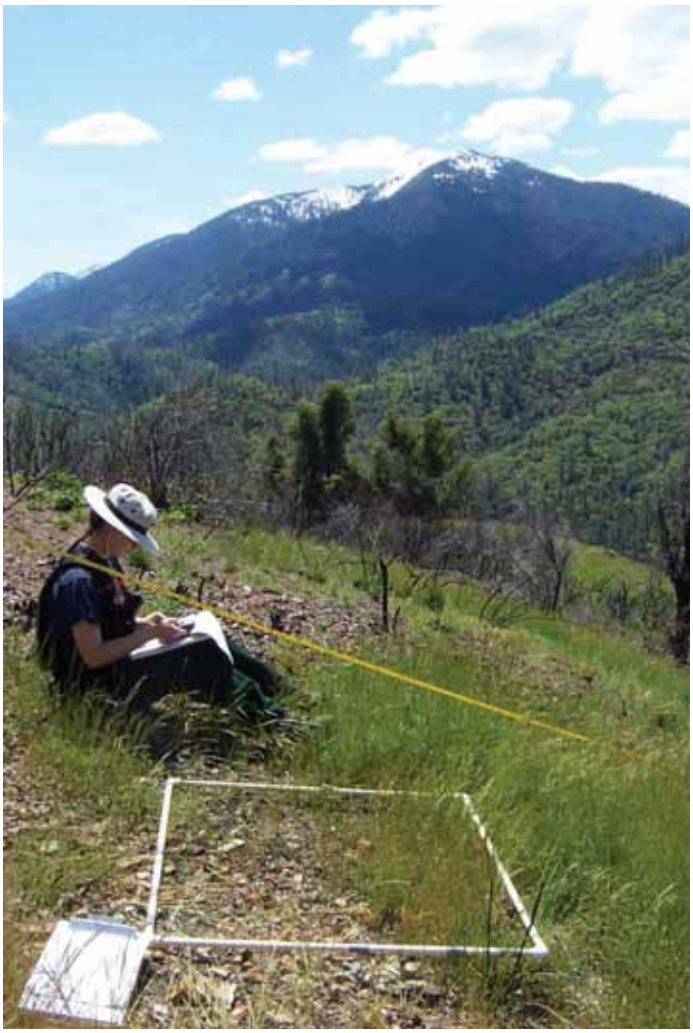

A biological science technician samples vegetation at Whiskeytown National Recreation Area to assess the response of both native and nonnative vascular plants to a 2004 wildfire. Video of the survey appears in the knowledge centers module on ecology of the Views of the National Parks program and helps illustrate the importance of science in understanding park ecosystems.

# Parks, plates, passion, and a professor

*By Katie KellerLynn and Judy Geniac*

**"THE GEOLOGY OF THIS NATIONAL PARK** is way too complicated." This is the occasional refrain of park staffs charged with interpreting sites set aside for their awe-inspiring geology. Bob Lillie's answer to this comment is "Yeah, but so is a lizard." Lillie, a professor of geology at Oregon State University, has served as a Geoscientists-in-the-Parks participant in eight units of the National Park System and as a seasonal ranger at Crater Lake (Oregon) and Yellowstone National Parks (Wyoming, Montana, and Idaho). He has taken on the "geologic cause" of training park staffs about geology in their parks. "You get a lot of great talks about bears and flowers, but geology gets … short shrift," says Lillie.

Since beginning a yearlong sabbatical in August 2005, he has been collaborating with local experts and NPS geologists and leading a series of 45 geology workshops in parks for interpreters and other interested staff. His geologic-training adventure began in Golden Gate National Recreation Area (California), then shortly thereafter he traveled to Rocky Mountain National Park (Colorado). Lillie's passion will take him to national parks, monuments, and seashores across the nation; he will spread the word that national parks are places where dramatic geologic events are taking place. For example, as he says in the preface of his new book, *Parks and Plates: The Geology of Our National Parks, Monuments, and Seashores*, "People can go to parks in California to observe changes in the landscape associated with earthquakes. They can see volcanic eruptions and their products in the Pacific Northwest, Alaska, and Hawaii. In national seashores they can see effects of erosion and deposition."

*[Bob] has taken on the "geologic cause" of training park staffs about geology in their parks.*

Lillie explains that "the geologic forces that influence our lives are especially vivid in national parks—about half of which were established because of their spectacular geologic features." *Parks and Plates*, published in 2005 by W.W. Norton, is intended for visitors to the National Park System and for park staffs in interpretation, natural resources, and research. His book is already popular in some of the 150 or so courses on the geology of national parks taught at colleges around the nation. "If we can use the compelling stories of geology in our national parks to hook people into learning more about our natural world, that's great," Lillie says.

His dedication is exemplified by a sabbatical committed to training workshops and his book, which presents geology in a way that speaks to a general audience. To Lillie "food analogies are good." An accomplished Cajun cook, he recalls growing up in Cajun country with his mother's and grandmother's cooking. "They always started by making a roux—a mixture of hot oil and flour. The more flour added, the thicker and more pasty the roux. Magma is similar, only the thickening agent is silica." He also uses Oreos to explain plate tectonics: the hard cookie representing Earth's rigid plates and the creamy filling representing the asthenosphere (the "zone of mobility" below the plates where magma is generated, isostatic adjustments take place, and seismic waves are strongly attenuated).

Professor of geology Bob Lillie at Dream Lake, Rocky Mountain National Park, Colorado.

On his way to New Orleans to help in hurricane recovery efforts, Lillie stopped at a conference and accepted awards from the National Park Service. He and his university, Oregon State, each received a plaque of appreciation for three important ways they have been helping parks: volunteer work, a focus on having graduate students work with national parks to create geology training manuals, and development of a program to certify students in geologic interpretation.

In cooperation with the National Park Service, Bob Lillie saw a need and is on a quest to fill it. "There are major issues affecting society, such as fossil fuel use, earthquakes, pollution, and global warming, that all relate to geology," he says. "Most park interpretive rangers have backgrounds in biology or social sciences, but rarely geology. The Park Service recognizes the need to do more to tell the geological stories that shape the spectacular scenery of national parks." Professor Lillie is taking the lead to help NPS staff understand the geology of the park areas they serve. ■

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# 7 Profiles in Natural Resource Leadership

The National Park Service is proud to honor its employees who make important contributions to the perpetuation of park natural resources. In this chapter we recognize winners of the Director's Awards for Natural Resource Stewardship. Given in 2005 for work performed in 2004, these awards recognize the outstanding natural resource conservation achievements of two park superintendents, two resource managers, a facility manager, a natural resource researcher, and a program administrator. Though the awards celebrate individual achievements, the award winners call attention to teamwork, professionalism, and a shared sense of purpose among park staffs—critical qualities in the successful management of national parks—in the profiles that follow. To make these qualities come together successfully, however, means that each of the awardees also shares a special attribute with the others: leadership. As a group they have succeeded in articulating a compelling vision of park resource management and protection. They have integrated ideas and motivations to advance resource understanding. They have overcome obstacles and drawn support for protecting the values and natural resources of the national parks. Courageous and innovative, they are leaders in natural resource stewardship.

*"We National Park men and women know that nature's work as expressed in the world-famous regions in our charge cannot be improved upon.... We have the spirit of fighters, not as a destructive force, but as a power for good. With this spirit each of us is an integral part of the preservation of the magnificent heritage we have been given."* — **Horace M. Albright**

# Gutsy leadership preserves natural resources at two very different parks

**THE DIRECTOR'S AWARD** for Superintendent of the Year for Natural Resource Stewardship recognizes outstanding contributions in natural resource management by a National Park Service (NPS) superintendent. The award was created not only to recognize but also to foster innovative resource management support and direction. Harder qualities to measure are an unwavering commitment to the NPS mission and an extraordinary ability to navigate complex and highly contentious issues, which are the hallmarks of the joint recipients of the 2004 award, given in 2005: Tomie Lee and Paul Hedren.

Superintendent Tomie Lee credits her great staff and the support of both the regional and national NPS offices for her ability to put park resources first. "Glacier Bay brings out a deep commitment to place in the people who work here. Together we are doing everything that we can to keep this wonderful place as pristine as we found it," says Tomie proudly.

*Tomie Lee and Paul Hedren demonstrated gutsy leadership in the face of tremendous challenges in order to preserve the natural resources in their care.*

As superintendent of Glacier Bay National Park and Preserve, Alaska, Tomie has been at the center of a number of controversial issues, including the creation of a commercial fishing compensation plan. Commercial fishing in the park had been hotly debated for 40 years largely because of its economic importance to fishers and the desire of the National Park Service to protect marine resources in designated wilderness waters. To address the conflict, Congress passed legislation in 1998 that phased out commercial fishing in Glacier Bay proper in exchange for allowing commercial fishing to continue in the outer waters of the park and the payment of some $23 million to the potentially affected parties. Under Tomie's leadership the park developed a fair and final compensation program by working closely with fishers and the State of Alaska. The effort resulted in payments in 2003 and 2004 that were crucial to holding together the fragile coalition that had resolved the park's most long-standing and contentious resource issue.

Tomie's commitment to resource protection was evident in the development of a vessel management plan and preparation of an environmental impact statement (EIS) that examined providing park wilderness through a land exchange for a hydropower project. Despite vociferous opposition, park staff presented a plan that sought vessel management changes designed to conserve marine life, especially the endangered humpback whale (*Megaptera novaeangliae*) and Steller sea lion (*Eumetopias jubatus*), and included speed restrictions, pollution controls, and quotas on the number of vessels, including cruise ships. In the case of the land exchange, the legislation that would make it possible required an EIS showing that such an exchange would have no adverse impact on the park. In the face of political pressure, Superintendent Lee insisted that the document thoroughly explore and fully disclose potential effects on the park.

Superintendent Tomie Lee (holding award) and her staff.

Superintendent Paul Hedren.

Navigating controversial issues to ensure the protection of park resources "takes real dedication and understanding from everyone on the team," notes Superintendent Lee. She adds, "Clear goals are essential and everybody has to work toward the same thing, communicate those goals, and live up to the promises made."

The other award winner for the year is Paul Hedren, the superintendent of the Missouri National Recreational River. Composed of two separate stretches of the Missouri River, the park encompasses some 126 miles (203 km) of Missouri River and tributaries and some 34,000 acres (13,770 ha) of Nebraska and South Dakota. The Missouri National Recreational River is tiny in comparison with the 3.3 million–acre (1.3 million ha) Glacier Bay National Park and Preserve, but its resources are just as worthy of protection. Like Superintendent Lee, Paul resolved to protect park resources when he challenged a well-established bank stabilization program and a plan to create artificial sandbar habitat in the park.

Paul found himself in the unenviable position of trying to balance seemingly contradictory legal mandates. On the one hand, the park was added to the National Wild and Scenic Rivers System in 1978, and the Wild and Scenic Rivers Act prohibits the construction of any water resource project that would have a direct and adverse effect on the values for which the park was established. These values include the free-flowing condition of the river, recreational opportunities, and fish and wildlife. On the other hand, the US Army Corps of Engineers (the Corps) is charged with implementing certain bank stabilization in the park (itself a congressionally permitted but limited compromise to the Wild and Scenic Rivers Act) and creating sandbar habitat for endangered terns and threatened plovers. As originally proposed, both efforts would require the use of heavy equipment that could damage wildlife habitat and species, disrupt recreational activities, and change the park's shoreline unnaturally.

"We were and are all for the threatened and endangered birds, but my staff and I were also concerned about other indigenous [species]

like mussels, which are an indicator species and relatively rare in this part of the river. We felt pretty strongly that the Organic Act and the Wild and Scenic Rivers Act required the protection of *all* park resources and that the goals the Corps was trying to reach could be accomplished in many ways," says Superintendent Hedren.

For failing to sign off on the solutions as proposed by the Corps, Paul was labeled "inflexible," "too passionate," and "unable to compromise." Nevertheless, he initiated an effort that included inventory, research, education, and policy review to find less intrusive solutions. As a result the park has been able to identify areas where certain stabilization efforts will be most successful and perhaps even beneficial, and also to champion alternative bank stabilization techniques. Similarly, the park identified less invasive methods for creating sandbar habitats, such as modifying the flow regime and removal of early successional vegetation on existing islands through mowing, disking, and applying herbicides.

"I'd reached a stage in my career where I felt free to do the right thing, despite the consequences," says Paul, "and the right thing to do was to support the staff and take the heat to protect them. Even in hindsight, I am proud that I was there."

Above all, in winning this year's award, Superintendents Tomie Lee and Paul Hedren demonstrated gutsy leadership in the face of tremendous challenges in order to preserve the natural resources in their care. But as they pointed out themselves, these award winners are reflective of the many men and women of the National Park Service who are deeply committed to the agency's mission and to doing the right thing. ■

—Lara Schmit, Associate Editor, *Natural Resource Year in Review*, contractor to the National Park Service

## Ed Walls: A leader in environmental management

Ed Walls, chief of Facility Management, Point Reyes National Seashore, California

Point Reyes National Seashore is a "Center for Environmental Innovation." National Park Service headquarters in Washington, DC, designated Point Reyes as a park that is a showcase of sustainable practices, largely because of the talents and dedication of Edward J. Walls, chief of Facility Management at the park and recipient of the 2004 Director's Award for Natural Resource Stewardship through Maintenance, given in 2005. Ed has been part of what he calls a "culture change" at the park, an approach to natural resource management that emphasizes, as he says, "conserving energy and stepping lightly on the landscape."

Innovation can be difficult if park staff is reluctant to make changes. A 2003 workshop called "Greening of Point Reyes" gave park staff an opportunity to embrace the concept of doing things differently. Ed took the roles of both coordinator and cofacilitator for the event, sponsored by the National Park Service and the US Environmental Protection Agency, to develop a vision of goals and strategies for the next five years for the park and the local community. One outcome was that park staff had the opportunity to participate in shaping the vision of the park's future and thus felt ownership in the greening initiative and more receptive to changes.

Those changes include the capacity to generate 25 kilowatts per hour, approximately 8% of the park's total energy needs, from five solar power systems installed at sites throughout the park, saving $9,000 to $10,000 a year on fossil fuel costs. The park's fleet now includes six electric and two hybrid vehicles, an electric charging station, and a propane gas station to service propane-fueled trucks. Gasoline-powered vehicles are being converted to run on re-refined oil, and the hydraulics stream in heavy equipment now runs on vegetable oil rather than petroleum-based oil. The park uses only green custodial products, recycled paper, and recy-

cled plastic lumber for deck treads and picnic tables. Selectively placed lighting retrofitted with compact fluorescent tubes now maintains the dark of the night sky. These innovations came about under Ed's leadership in obtaining funding from and working with many different government and corporate sources. His efforts have led to the park's selection as one of two prototype areas in the Pacific West Region for its environmental management system because of its exemplary practices of recycling, purchasing, hazardous materials handling, alternative fuel use, and green design.

*Point Reyes is a leader in natural resource restoration and sustainability because of the vision of Ed Walls and the park staff who works with him.*

Ed has also played an important role in the park's natural resource restoration. His crews have restored creek habitat at several locations, eliminating barriers to migration of coho salmon and steelhead trout (both on the federal list of threatened and endangered species) and opening areas to spawning. Larger projects are the coastal watershed restoration in Drake's Bay, the Giacomini marsh restoration that will increase central California's coastal wetlands by 12%, and dune restoration. Removal of exotic grasses from one dune area has resulted in an increase of native species and use of the area by the western snowy plover, a federally listed shorebird (see article, page 91). Work in the dunes is especially challenging because it requires heavy equipment without damaging environmentally sensitive dunes or the endangered species they harbor. Creek, marsh, and dune restoration techniques developed at Point Reyes are now being used at other parks and are models for other agencies, including California State Parks. Point Reyes is a leader in natural resource restoration and sustainability because of the vision of Ed Walls and the park staff who works with him. ■

—Betsie Blumberg, Associate Editor, *Natural Resource Year in Review*, under cooperative agreement with the National Park Service

## Protecting small-park resources from Big Island development in Hawaii

**PROTECTING INVALUABLE SMALL-PARK RESOURCES** from burgeoning Big Island development, Sallie Beavers, marine ecologist at Kaloko-Honokōhau National Historical Park, credits teamwork. "I'm just the worker bee in the background helping out. It's a complete team effort here." Sallie's leadership role in this team effort earned her the 2004 Trish Patterson–Student Conservation Association Award for Resource Manager in a Small Park, presented in 2005.

Originally from New Orleans, Sallie joined the park team in 2001 and wasted no time getting down to the business of protecting the park's marine and terrestrial resources. At the time, park resource managers were in the process of presenting their concerns to the Hawaii Land Use Commission regarding a proposed industrial park upslope of Kaloko-Honokōhau. Pollutants from the site could impact native species and water quality in the marine and brackish water environments at the park. Sallie presented research findings and expert testimony that helped make the case for park resource protection. "We didn't try to stop the development; we just wanted conditions imposed to protect our resources. We won," Sallie says. "It was a landmark case in Hawaii and it was all because the superintendent, Geri Bell, and the resource manager, Stan Bond [who won this award in 2002], saw the potential threats and got involved to protect this park." Participating in the effort

Sallie Beavers (right) and University of Hawaii graduate student Tim Clark prepare to install equipment to monitor movements and habitat use of green sea turtles, manta rays, jack trevally, and tiger sharks at Kaloko-Honokōhau. The project is a joint effort among the National Park Service, the University of Hawaii, and the Hawaii Division of Aquatic Resources.

reinforced her commitment to protecting park resources. "It also made me see that I can make a difference and be a part of something larger than myself."

Kaloko-Honokōhau, a small historical park increasingly surrounded by development, is only 1,160 acres (470 ha) in size. However, it is home to numerous cultural and natural resources, including a unique ecosystem of anchialine (brackish water) pools, a pristine coral reef system, two fishponds, and many marine and terrestrial species (11 of which are listed as threatened or endangered). Sallie plays an instrumental and varied role in protecting these resources. "We're a small park, so I have to wear more than just the marine ecologist hat. My job has evolved into anything and everything that has to do with land-sea interactions that may affect water resources."

A marine research specialist, Sallie has built a highly effective coral reef program that analyzes and monitors groundwater flowing into the coastal environment. Native Hawaiian science students are involved in the program as interns, a partnership that is important for the park. Sallie's work has also focused on developing a program to remove invasive algae from park waters, and instituting a long-term monitoring program to assess green sea turtle health. Her proposals for water quality projects consistently compete well for funding and have been used as models on the national level. She has also contributed scientific research on a broad range of water ecology topics and has developed a network of partnerships with universities, government agencies, and nonprofits to expand park research and preservation efforts.

*"My job has evolved into anything and everything that has to do with land-sea interactions that may affect water resources."*

Sallie is passionate about protecting and enhancing park resources, even when the obstacles seem overwhelming. "Management policies tell us to, when appropriate, go outside park boundaries to work with our neighbors in order to protect the resources. That's certainly being done here. It would have been easy to say, 'Oh well, gosh, there's development coming in. What are we going to do?'" Instead, she has focused on doing her day-to-day job. "It's hard to drive down the road and see the bulldozers and know what's coming. But it's motivating for all of us here to see that we can do our job and protect the [park] resources." ■

—Kristina Woodall, Associate Editor, *Natural Resource Year in Review*, contractor to the National Park Service

## "Tromping around on glaciers": A profile of research ecologist Dan Fagre

**DAN FAGRE HAS CAUSED A CHANGE** of thinking at Glacier National Park, Montana. This USGS ecologist has helped park staff and resource managers around the world view mountain ecosystems more dynamically and recognize the impacts of climate change on natural resources. As stated in his nomination for the 2004 Director's Award for Natural Resource Research, "Dan has demonstrated vision and innovation in guiding the development of powerful new tools and capabilities for understanding the structure and function of mountain ecosystems and has been instrumental in applying these capabilities to new problems of national and international significance."

Dan received this prestigious NPS award for his research, which encompasses ecosystem modeling, changes in tree line (alpine ecotones), snow modeling, snow chemistry, and glacier-climate dynamics. He says the breadth of his research is "a sign of somebody out of control," but his results attest to a systematic, integrated way of thinking that reveals connections on a global scale. Indeed, researchers from around the world consider the model that Dan formulated at Glacier National Park—one of the longest-running, global-change research programs in a national park—worthy of emulation on an international scale. This research program is an innovative integration of glaciology, plant succession, climatology, and other disciplines to explicitly examine the influence of climatic change on an entire mountain ecosystem. It involves numerous collaborators and yields accessible and relevant information that can help managers and the public make informed decisions. In addition, his research provides baseline data that underpin the NPS Inventory and Monitoring Program.

The most immediate and direct application of Dan's research is the use of climate and snowpack information for both predicting conditions and scheduling work on the opening of the Going-to-the-Sun Road, an alpine highway that crosses the Continental Divide in Glacier National Park. This enables the maintenance division to work more safely and efficiently: staff does not start plowing the road until after maximum snow accumulation has occurred or until after the peak of avalanche hazards has passed. The avalanche research helps to improve long-range planning of operations and understanding of the many ecological effects of frequent snow avalanches.

*Dan considers himself to be on an intellectual adventure that is contributing to scientific and public understanding of mountain ecosystems.*

In addition to his scientific achievements, the Intermountain Regional Office selected Dan as a regional contender for the national award because of "his ability to 'outreach' to park staff and visitors." Indeed, the public has seen Dan on CNN, Fox News, ABC, NBC, and in documentaries on the Discovery, Travel, and National Geographic Channels. "Frankly," Dan says, "the main way that this has occurred is being willing to take the time to talk with the media." He goes on to say that not all scientists are willing to do this because the scientific community often does not value such efforts and some scientists fear being misquoted. However, Dan believes that the opportunity to convey science in an enthusiastic way outweighs the risks. In short, he holds that "science can be a very exciting story to tell."

One such story links the Pacific Decadal Oscillation—a 20- to 30-year climate cycle that influences snowpack—with hydrology, formation of avalanche chutes, habitat creation for grizzlies, plant succession, nutrient transfer to rivers, and effect on aquatic invertebrates. No wonder Dan sometimes feels "all over the map." Yet these types of connections are the reason he first started "tromping around on glaciers." His interest in finding and explaining connections leads to documenting the relationships and responses between the mountain ecosystem of Glacier National Park and other similar systems throughout the globe.

Dan considers himself to be on an intellectual adventure that is contributing to scientific and public understanding of mountain ecosystems. He feels privileged and content to be the global climate change research coordinator at the Glacier Field Station of the USGS Northern Rocky Mountain Science Center. According to his nominators, during his 14 years in this capacity Dan has "developed a program and a presence that the park cannot live without." ■

—Katie KellerLynn, Associate Editor, *Natural Resource Year in Review*, under cooperative agreement with the National Park Service

Dan Fagre, research ecologist, Glacier National Park, Montana.

# Resource manager for the ages: Yellowstone's John Varley

*By Tom Olliff and Paul Schullery*

**IN MARCH 2005**, Yellowstone Center for Resources director John D. Varley accepted the 2004 Director's Award for Natural Resource Management. John was recognized both for recent accomplishments and for the scope of his contributions to the National Park Service (NPS) throughout the course of his 30-year NPS career.

In 2004 he initiated Yellowstone's Molecular All Taxa Biodiversity Inventory (see article, page 63) and served as the project coleader on the Servicewide Benefits-Sharing Environmental Impact Statement, which could harness the power of science to assist the National Park Service in meeting its mission for resource stewardship and preservation.

In accepting the Director's Award for Natural Resource Management in March 2005, John Varley explained that his experience of more than 40 years in natural resource management had taught him "something about how to get things done in bureaucracies." He said, "I call them the four 'Ps,'" and they are "*passion*, because it's important to be passionate about your work; *patience*, because as we all know nothing happens too fast in government; *persistence*, because anything important to do has many barriers to overcome; and *partnerships*, because bureaucracies don't seem to want to move without the effort of an entire team." Sage advice.

For the past three decades John has been an acknowledged leader of NPS resource stewardship, a position he has earned by pushing for innovative resource programs on the ground, where they count. He has led several remarkable resource initiatives, including gray wolf restoration, putting the 1988 Yellowstone fires into ecological context, and being the primary architect in the 1970s for radical changes in Yellowstone's fishing regulations, many of which have been adopted nationwide. John also firmly established science and research as a foundation for resource management in Yellowstone through the creation of the Yellowstone Center for Resources (YCR) in 1993.

The establishment of the Yellowstone Center for Resources represented a new model for practicing natural and cultural resource management and research in Yellowstone. It improved professionalism in the natural resource arena and pieced together the park's long-neglected and disparate cultural functions into a cohesive professional team. John has also created a variety of professional vehicles for improving communication among researchers, resource managers, and the public. The flagship result of this effort is a series of well-attended biennial scientific conferences on the greater Yellowstone ecosystem, sponsored by the National Park Service in partnership with other agencies, universities, and professional societies. The eight conferences and seven large proceedings these partners have produced are perhaps the single most significant new source of scientific information on greater Yellowstone in the history of this region.

Among the other initiatives John has developed is the most aggressive and professional resource information program in the National Park Service. Its staff organizes the conferences and has produced many large milestone reports and books as well as the popular quarterly magazine, *Yellowstone Science*.

As YCR director, John manages some of the most high-profile, controversial, politically encumbered, and complex resource programs in the National Park Service, including joint bison management with the State of Montana, grizzly bear conservation, wolf reintroduction and recovery, elk management on Yellowstone's northern range, predicting hazards from the Yellowstone volcano, protecting Yellowstone's geothermal features, conserving the Yellowstone cutthroat trout, protecting aquatic and terrestrial resources from introduced exotic species, managing the natural resource aspects of wildland fire, and monitoring the impacts of oversnow vehicles on natural resources.

*[John] has led several remarkable resource initiatives, including gray wolf restoration, putting the 1988 Yellowstone fires into ecological context, and being the primary architect in the 1970s for radical changes in Yellowstone's fishing regulations.*

The thread that runs through all these accomplishments is John's passion for science and talent for applying scientific solutions to resource stewardship problems. In each of these cases he has let science lead the way. He has used it as the most fundamental platform to improve resource preservation, and in so doing has changed public attitudes, enabled the positive evolution of park and NPS policies, and facilitated the park's ability to initiate actions to solve real-time resource problems. John has earned a legacy that few will ever claim: he has made a lasting change in the way the National Park Service conducts the business of resource stewardship. Former Yellowstone superintendent Mike Finley summed it up: "John … is a forward-thinking and visionary kind of guy. He understands the language of science and he rolls it into practical action." ■

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# "Getting things done": The productive work life of Abigail Miller

**IN 18 YEARS OF WORKING** for the National Park Service, Abigail Miller has never thought of herself as a technical specialist, the kind of person to whom the Director's Award for Professional Excellence in Natural Resource Stewardship is typically given. "I'm a big-picture person," she says, "with a tendency toward pragmatism, and interested in tweaking processes to get things done." Nevertheless the National Park Service honored her with this prestigious award in 2005, recognizing her gifts as a manager and leader of a broad variety of natural resource programs and initiatives that have left the National Park Service much better off with respect to its natural resource conservation mission than when she first came to the organization as a program coordinator in 1988. She retired in 2005 after serving for 10 years as deputy associate director for Natural Resource Stewardship and Science.

Abby combines the characteristics of a visionary with those of a detail person, skills that helped guide the National Park Service through a period of tremendous growth for natural resource stewardship programs in the 1990s and early 2000s. During her tenure the Park Service implemented inventory and monitoring, instituted numerous professional and integrative business practices as part of the highly successful Natural Resource Challenge initiative, improved the National Park Service's performance-based accountability for natural resource management activities, and helped focus fiscal resources where they were most needed. She attributes her success in these areas to her expertise in the federal budget process. She says, "I was a GS-5 when I figured out that you need an understanding of the budget process in order to get things accomplished in government."

*Abby regards helping to strengthen the professionalism of the natural resource workforce as the most significant development in her career with the National Park Service.*

She also credits her success to focusing on the big picture, paying attention to the mechanisms required to get things accomplished, and involving those affected by or having an interest in the task at hand. About 10 years ago, Abby and a colleague in the NPS Budget Office discussed the need to expand professional natural resource staffs, particularly at small parks where filling scientist positions had lagged behind other needs. From the time of this budget initiative in FY 1993–1994 and the Natural Resource Challenge as of 2003, professional natural resource staff in the Park Service more than doubled. "The level of professionalism is much higher now," she observes, careful to point out that she alone was not responsible for the change. "Instead of being a small, somewhat isolated program, the natural resource management program has a real presence and is widely recognized as effective." Along with the Inventory and Monitoring Program, which operates 30 of 32 planned monitoring networks (see article, page 27), Abby regards helping to strengthen the professionalism of the natural resource workforce as the most significant development in her career with the National Park Service.

Abby Miller, winner of the Director's Award for Professional Excellence in Natural Resource Stewardship.

Abby hopes that NPS employees will learn from the success of the Natural Resource Challenge and cites involving park superintendents and the deputy director as critical in its success. "What made this initiative work was that it became a National Park Service priority, not just a natural resource management priority," she says. "The more you broaden support for initiatives and link them to a wide variety of park management concerns, the better off you'll be."

In nominating her for this award, Abby's coworkers could have been describing the conductor of an orchestra, one who also plays many of the instruments. Abby kept track of the professional activities, specialties, and information needs of hundreds of people around the country in the National Park Service and partner organizations, Congress and the Office of Management and Budget, and other key contacts. She gave input on many important management issues, suggested new approaches to business practices, directed change, and kept her staff informed and prepared. Her skills in budget formulation, project management, accountability, and policy were all very important in keeping processes moving ahead in a timely fashion. The result was a symphony that Abby was an important part of conducting, one that will be recognized for decades as an especially productive period for strengthening natural resource management programs in the National Park Service.

Abby credits the mission of the National Park Service as a very motivating force in her work life and still has a passion to visit national parks. Since retiring and moving to Vermont in March 2005, she has been to eight "new" parks, including Women's Rights National Historical Park, Hubbell Trading Post National Historic Site, and Joshua Tree National Park. Though still adjusting to the new change of pace, Abby is productive and energized. She serves as the program chair for the 2006 biennial conference of the George Wright Society and is involved in several volunteer organizations. She and her husband, Bob, enjoy hiking, cross-country skiing, and activities with friends, and she is busy reading all the books she received as retirement gifts, and then some. ■

—Jeff Selleck, Managing Editor, *Natural Resource Year in Review*

# Index

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**1–6** (epigraph) D. F. Rettie. 1995. Our National Park System: Caring for America's greatest natural and historic treasures. University of Illinois Press, Urbana. Page xiii.

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# Natural Resource Year in Review–2005

www.nature.nps.gov/YearInReview
ISSN 1544-5429

**Published by**
National Park Service
U.S. Department of the Interior
Natural Resource Program Center
Denver, Colorado,
and Washington, DC

D-1755/April 2006

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Dennis | Konetzka | Design Group, contractor



The *Year in Review* is published electronically on the World Wide Web (ISSN 1544-5437) at www.nature.nps.gov/YearInReview.

For a printed copy contact the managing editor by e-mail or write:

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



**Suggested article citation**
Blett, T. 2006. Determining risk of airborne contaminants to western national parks. Page 41 in J. Selleck, editor. Natural Resource Year in Review—2005. Publication D-1755. National Park Service, Denver, Colorado, and Washington, D.C.

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**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-1755/April 2006

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