1992 Highlights of Natural Resources Management

Natural Resources Report NPS/NRPO/NRR-93/10

United States Department of the Interior
National Park Service
Natural Resources Publication Office

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Introduction

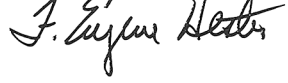
Nineteen ninety-two proved to be an exciting year for those of us concerned with natural resources management. The year opened with natural and cultural resource management personnel meeting to explore new ways to work together. It ended with the National Park Service responding to the report of the National Academy of Sciences on research in the Park Service. Both of these events were linked by the completion and initial implementation of a five-year strategic plan for natural resources. The larger purpose of each of these activities was to identify and implement strategies for improving the management of natural resources in the Park Service.

Implementing a recommendation made at the Vail Symposium, the Cape Cod conference brought together natural and cultural resource management staffs from all levels of the National Park Service. Participants shared ideas and searched for ways to improve communication and cooperation. The articles in this report on the resource management in cultural sites illustrate how closely entwined natural and cultural resource management issues can be and indicate the need for continued efforts to assure that the two programs complement each other.

Two key components of the National Academy of Sciences report, the Vail Symposium report, and the strategic plan concern developing professional research and resource management staff and providing that staff with sound scientific data. The days are gone when park designation was 90% of the solution to preserving and protecting resources. The complex jobs facing many parks today--resource protection, visitor protection, interpretation, and visitor services, as well as resource management--are great and require much expertise; we must increase our professional capability to handle them all effectively. Park managers must respond to ever-increasing stresses from inside and outside the park, and many resource conflicts end up in court. Generalists will continue to be an important element in park management, particularly in small park areas, but specialized expertise, training, and full-time attention will be required to carry out protection, interpretation, and resource management functions in many of the larger, more complex park units. For resource management, that means that additional biological, hydrological, paleontological, and other resource disciplines must be applied. In the section discussing resource management, we can clearly see the challenges facing resource managers today.

Research is essential to develop sound management practices, as is discussed in the research section of the report. The articles on research and geographic information systems show some of the highly technical resource management activities that are ongoing in parks and demonstrate the use of research data to implement resource management activities. The section on exotics shows how managing exotic species puts Park Service expertise to the test. Managing exotics requires not only extensive research and resource management skills, but also budgetary skills: exotic plant and animal control combined is currently the single greatest identified unfunded need in the National Park Service.

As national attention focuses on the threats to natural resources, the National Park Service's commitment to protecting its resources will only grow stronger and the Park Service will continue to improve its ability to provide protection for these resources.



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Big Events in '92

The Natural Resources Strategic Plan: Blueprint for Progress

By Napier Shelton, Technical Publications Writer-Editor, Wildlife and Vegetation Division

The National Park Service Natural Resources Program should take a great leap forward in the next few years, propelled by the 1992 Natural Resources Strategic Plan. If all objectives are met, natural resources programs throughout the Park Service will have much stronger organization, funding, staffing, and expertise; a more credible and focused mandated research program*; systematic inventory and monitoring activities in many parks; long-term, ecosystem-level research; coordinated, linked data management systems; and growing public and professional support for the National Park Service's natural resources activities. The ultimate payoff will come when park staffs bolstered by this backing improve the actual management of park resources.

The Natural Resources Strategic Plan responds to recommendations on resource stewardship from the National Park Service 75th Anniversary Symposium held at Vail, Colorado, in October 1991. It also addresses the recommendations of the National Academy of Sciences' National Research Council report, *Science in the National Parks*. The strategic plan was put together over a two-year period (initiated before the Vail Symposium) by the Natural Resources Directorate with the help of regional and park natural resource personnel and reviewers throughout the Park Service. By the fall of 1992, nine teams, including members from all levels of the Park Service, had been assembled to carry out the plan and had started to work.

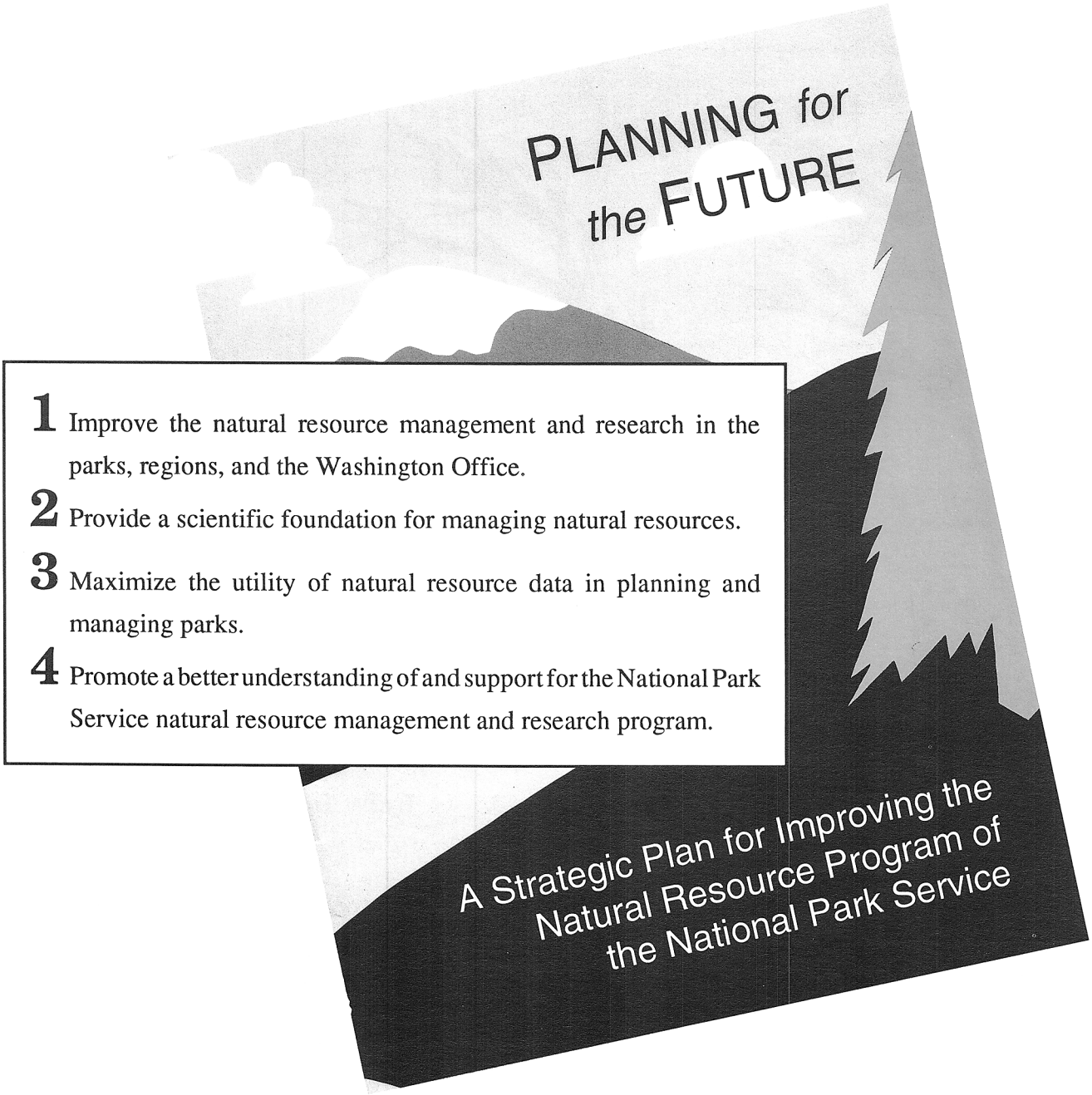
The Implementation Plan lists over 80 products to be completed between 1992 and 1996. More than 20 of these were completed in 1992. These range in scope from broad, far-reaching recommendations to narrowly focused products. Many of these products require approval by the Directorate before they become operational. A few examples are described below.

Response to Recommendations* Of major importance to National Park Service research are the steps taken to implement recommendations of the National Academy of Science's report. A task force composed of regional and associate regional directors, associate directors, superintendents, and scientists reviewed that report, made recommendations to the Director, and developed a plan to carry out the accepted recommendations. The plan includes some far-reaching changes, such as requiring supervision of park scientists by regional research personnel where this is not already the case, drafting a legislative mandate, and creating separate research organizations and budgets. Other portions of the plan would reinforce or expand current efforts, such as the inventory and monitoring program and the inclusion of researchers in development of resource management plans.

Accomplishments in 1992 A team led by Ron Hiebert, Chief Scientist, Midwest Region, tackled the matter of organizational structure, focusing on the Washington Office. The team made specific recommendations for positions under the Associate Director, Natural Resources, and also general recommendations about model structures for regions and

Big Bend Reorganization Fits Into Strategic Plan

In response to the need for sound data and increasingly specialized disciplines, many parks as well as some regions are actively considering separating resource management from the protection function. In the 1991 Highlights Report, Big Bend Superintendent Rob Arnberger outlined a number of improvements he hoped to implement despite failure of a major funding proposal. One of the changes was a reorganization of resource management functions, which had been identifed as a need during planning for participation in the Servicewide Global Change initiative in 1990. In August 1992, Big Bend's former Division of Resources Management and Visitor Protection was split to form a new Division of Science and Resources Management. The new Science and Resources Management Division is responsible for both natural and cultural resources, including air quality, water resources, and GIS.



parks. Closely related to the model organizations are the role and function statements developed by the team under Bruce Kilgore, Chief Scientist, Western Region. These statements cover the park, regional, and Washington Office natural resource positions.

Up to now, requirements for peer review of research proposals have been determined by regional offices. Sam Kunkle, Chief Scientist, Southwest Region, leads a team charged with developing "a required peer review process for evaluating research proposals from all researchers...seeking funding." The team has drafted a proposed policy to apply Systemwide that includes as research the development of inventory and monitoring protocols and follow-up data analysis techniques.

Most people would probably agree that the Natural Resources Trainee Program, now working with its sixth class, has taken a quantum leap in upgrading National Park Service expertise in natural resource management. This was acknowledged by the team led by David Haskell, Chief of Resources Management, Shenandoah National Park. This team evaluated whether the program had met the basic original program objectives. The team also assessed the Team Resources training program, which since FY 1988 has provided orientation on resources management to park employees but received no funding in FY 1992. The team found through a survey that the program has been very useful and made recommendations about its continuation. Additionally, this training team drafted a curriculum for a course on resource management policy for new managers.

**The five-year Strategic Plan and its initial products predated the Secretary of the Interior's National Biological Survey proposal. Adjustments must be made to reflect changes in the organization of Department of the Interior biological research activities.*



After The Storm

By Pat Tolle, Public Affairs Specialist,
Everglades National Park

In the early morning hours of August 24, 1992, Hurricane Andrew bulldozed its way across the south Florida peninsula. With unwavering westward movement, Andrew took dead aim on Biscayne National Park and then roared across the northern two-thirds of Everglades National Park and the southern half of Big Cypress National Preserve. The residents of the area, including some 250 park employees, were faced with mind-numbing damages and no resources to begin recovery. Total destruction of structures extended not for blocks, not for neighborhoods, but for miles and miles. The exact velocity of the winds--the measure by which we evaluate the strength of a storm--may never be known; the resulting catastrophic destruction will never be forgotten.

But what of the parks? Although a major hurricane had not made landfall in this specific area in some 30 years, anecdotal information and historic records tell us that such storms have occurred with some regularity, and that their powerful force for change has been a significant factor in shaping the Everglades landscape as we know it today.

To determine the effects on park lands and to direct recovery efforts, the National Park Service sent its Type I All Risk Management (ARM) Team to south Florida. Their immediate charge was to provide basic emergency assistance to the employees and families of the parks. This was followed by the need to determine the extent of damages to facilities and resources, and how best to address them. Obviously, structural damage was extensive; a team from the Denver Service Center inventoried all facilities, evaluated their condition, and provided repair cost estimates or condemned for removal.

The ARM Team made the decision to assemble a second group to assess the natural resources damage. Led by Gary Davis from the National Park Service Cooperative Park Study Unit, University of California, Davis, a team of 25 experts from throughout the Park Service, other agencies, and the academic community gathered in south Florida just three weeks after the storm. The scientists, most of whom had previously worked or studied in Florida parks, spent two intense weeks in the field evaluating damage to marine, freshwater, archeological, and upland resources as well as the impacts of clean-up efforts.

The initial summary of their work provided park managers with a concise inventory of immediate effects of the hurricane. It dispelled many of the myths of wildlife mortality and catastrophic devastation with facts. The largest single wildlife incident was the death of some 200 wading birds--mostly white ibis and egrets--in Biscayne Bay. The larger animals, including the endangered Florida panther, were relatively unaffected. The inventory provided numbers of downed trees versus those still standing, and the percent-

age that could be expected to survive. There was good news about submerged cultural resources, which experienced little damage, and bad news concerning movement of artificial reef materials onto sensitive corals. The data also provided indicators of future problems: more than 70,000 acres of mangroves--critical wading bird rookery habitat--flattened, and 90% of the nesting sites for the red-cockaded woodpecker destroyed; the potential increased for extensive spread of exotic vegetation species into previously unaffected areas; and new threats to air and water resources in the parks from disposal of hurricane-generated debris. (For further details of effects on vegetation and exotics, see following article.)

Beyond documenting actual storm-related conditions, the resource survey detailed immediate actions to monitor recovery and made specific recommendations to protect exposed cultural resources and to remove exotic animal and plant species. The third element described long-term actions necessary to understand resource dynamics and evaluate the relative effects of human activities and those of extreme natural events like hurricanes on park natural resources in south Florida.

In retrospect, the ARM Team's early identification of the need for a natural resource damage assessment and the subsequent activation of the task force must be viewed as major accomplishments. A delay of even a few weeks would have meant the loss forever of a wealth of information. The opportunity now exists to monitor ecosystem recovery in the Everglades, based on extensive pre-storm data at the South Florida Research Center. This may prove to be the most thorough scientific study of the immediate, short-term, and long-term effects of a catastrophic natural event ever accomplished.

Exotic Plant Species Spread by Andrew

By Robert F. Doren, Assistant Research Director, Everglades National Park

On August 24, 1992, Hurricane Andrew hit southern Florida. With official sustained wind speeds of 164 mi/hr and gusts of over 198 mi/hr, Andrew moved across the southern tip of the Florida peninsula at speeds of about 15 miles per hour. Everglades National Park, Biscayne National Park, and the extreme southern end of Big Cypress National Preserve suffered heavy damage, as did the human communities of southern Dade County.

The most severely affected resources of the parks were the vegetation communities. Hardwood hammocks, mangroves, and pinelands were hardest hit, while prairies and cypress stands were the least affected. The worst damage occurred within the 30-mile diameter eye and 10 miles on either side, damaging virtually all of the hardwood hammocks and pinelands and the western mangroves along the Gulf of Mexico in Everglades, all of the hardwoods and mangroves in Biscayne, and the southern tip of pinelands and mangroves in Big Cypress.

The results of an initial post-hurricane assessment of the pinelands shows approximately 33% of the trees were felled by the storm with a range from about 20% to 44%. Trees with larger diameters were more likely to have fallen than smaller diameter trees. Impacts on mangroves included a total loss of canopy and knock-down of over 70,000 acres of forest. The hammocks experienced total defoliation, with greater than 50% loss of trees or major canopy branches.

Under historical conditions, a hurricane's impacts would be neutral in regard to the natural resources and their recovery. Flux is very much a part of the natural Everglades. Unfortunately, we have an ecosystem that has been seriously affected by the actions of people and that no longer is a "natural" system. Parts of the ecosystem have been variously drained, flooded, polluted, burned, and chopped up into smaller parcels. Entire communities have been developed and exotic plants introduced for various reasons.

Of all these threats, the hurricane has the greatest chance of increasing the spread of exotic species. *Melaleuca* forests east of the park were blown down, the trees defoliated, and all the seed capsules spread westward over the park. The power of 164 mph winds to disperse items may be difficult to grasp; this example may give some perspective. The morning after the storm, I found the bed of a pick-up truck inside my garage; it had been thrown through my garage roof from over 4 miles east of my house. *Melaleuca* seed capsules are 1/2" in diameter and 3"-4" long and could easily be spread across the entire park by such winds. The same thing happened to all of the Australian pine trees east of the park. In 1960, Hurricane Donna caused the same level of damage in mangroves as Andrew, which resulted in a burst of Australian pine establishment on Florida Bay keys and along the entire Florida Bay and Gulf coasts of the park.

Although Brazilian pepper does not seed during hurricane season, it may still spread as a result of the storm. The last surge in population of Brazilian pepper occurred in the mangroves along the park's west coast after a severe freeze in 1979 killed several thousand acres of mangroves. Hurricane Andrew has essentially accomplished the same thing. Research suggests that most hardwood hammocks contain seedlings and saplings of Brazilian pepper. In addition, research conducted in hammocks opened up by fire indicates that Brazilian pepper seedlings and saplings are growing rapidly and may well capture the canopy. While low densities of Brazilian pepper seedlings in undisturbed hammocks may not be an immediate problem, the plants are ready to take advantage of additional light that results from impacts like those inflicted by Andrew.

(Continued)

Within the next year or two, we may well see a substantial increase in exotic plant infestations throughout the Everglades region affected by Hurricane Andrew. Areas that have already been cleared of invasive exotic plants may experience a resurgence and will need greater scrutiny. Areas that are not clear will see an increase in population density and areal coverage.

To manage this serious threat, we need to determine locations and rates of spread of *Melaleuca*, particularly in the east Everglades and Taylor Slough prairies, hammocks, and bayheads; of Brazilian pepper in the mangrove-marsh ecotone and adjacent areas; of Australian pine in Florida Bay and along the coastal beaches and keys; and of *Colubrina* along the Florida Bay coastline. Densities, survival, recruitment, and growth rates of exotic species should be determined, and relationships to understory environmental conditions analyzed. Long-term monitoring plots need to be set up in representative plant communities to determine invasibility and relationship to disturbance regimes. Modeling exotic pest plant succession, distribution, and spread characteristics is vital to understanding and developing control strategies. And, last but by no means least, these data should be used to develop a comprehensive management program. Developing a data base useful for evaluating the potential for exotic species establishment and continued spread within recovering communities is essential to developing cost-effective and productive management strategies.

Wildlife Health Program Provides Valuable Data

By Sharon K. Taylor, Wildlife Veterinarian, Wildlife and Vegetation Division

Infectious organisms can be devastating to the health of wildlife populations. While some diseases are natural components of the ecosystem, diseases introduced into wildlife populations by domestic livestock or captive wildlife can present significant obstacles to effective wildlife management. Disease outbreaks can cause substantial wildlife mortality; some introduced pathogens have the potential to decimate native wildlife populations. Many wildlife diseases cause further actual and perceived problems when they are transmittable to domestic animals and/or humans. Wildlife showing disease signs may also detract from the aesthetic value of wildlife and convey to uninformed publics a perception of mismanagement.

It is critical to understand the native and exotic disease processes affecting native wildlife to make informed management decisions. A 1989 survey of 138 National Park System units indicated that a majority of units had encountered animal disease-related issues and needed expert assistance in handling them. In July 1991, the National Park Service Wildlife and Vegetation Division hired a veterinarian to begin identifying critical wildlife health issues.

Yellowstone National Park was the first to use this new professional expertise. In December 1991, the Park Service's veterinarian began assisting Yellowstone National Park staff with the task of collecting extensive biological samples from bison that were being shot outside of the park. In a comprehensive bison health survey, the samples were screened for 11 different diseases and analyzed to establish normal blood values, identify parasites, culture bacteria, analyze tissues for gross pathology and histopathology, collect genetic information, and determine nutritional status. The information gathered will provide baseline health data on the bison for comparison with future surveys. This data will assist resource managers in monitoring changes and identifying which diseases are native and which exotic.

The surveys acted as a catalyst for Yellowstone to begin a comprehensive disease survey and monitoring program for other wildlife species. This Wildlife Health Survey Project, funded by the Wildlife and Vegetation Division, could serve as a prototype for the National Park Service. When animals are found deceased in the park or handled for management purposes, park staff members collect biological samples, conduct disease surveys, and bank the samples for future survey needs. These samples will provide critical information to wildlife managers on the disease exposure and health status of the park's wildlife.

This sampling project is based on Yellowstone's conservation, public health, and research priorities. Resource managers have categorized the following issues to be addressed by the wildlife disease sampling program: threatened or endangered species recovery, public health and safety, protection of native species, cross-boundary issues, animal welfare, and improved baseline information.

To bank these and other Park Service biological samples, a Park Service serum bank has been created at the University of Idaho's Caine Veterinary Teaching Center. Lack of information, technology, and funding can prevent management from conducting diagnostic tests at the time of collection. Deep freezing the serum portion of blood samples provides a method of saving samples for many years. It may also allow researchers to study blood samples without handling wildlife. Over 1,200 samples were submitted in 1992.

Progress has been made toward developing a Wildlife Health & Veterinary Resources Program responsive to park and wildlife resource needs. Maintaining healthy wildlife populations is a fundamental component of sound wildlife management practices. National parks provide a unique opportunity to collect baseline information from free-ranging unmanaged wildlife populations against which to measure the effects of changes on wildlife.

Teachers in Tents: Taking Inventory of Acadia

By Lissa Fox, Writer/editor, Wildlife and Vegetation Division

In the pitch black of thick woods, eight bobbing headlamps rise and fall in semicircles of light. From the direction of one of the lights comes an excited call.

"I've found one...no, TWO!"

Seven beams of light turn and move toward the sound. As they converge, a pool of light grows around the caller, illuminating her prize. Two salamanders wriggle desperately in her hands, one a couple of inches long, one not even half an inch.

Someone takes the little salamander while the others identify, weigh, and measure the big one. It's a red-back, as are all of the salamanders caught in these woods tonight. After recording the information, the salamanders are placed gently back where they were found, and the group spreads out to continue the search.

By 2 a.m., the hunt is over and the group has caught and logged information on 40 salamanders. Everyone goes to bed and gets up four hours later to see what is in the small mammal live traps they had methodically laid the day before. After identifying, weighing, measuring, and recording information on six voles, they finally gather around to eat breakfast and excitedly discuss their findings.

Who are these diligent, hard-working researchers, refusing sleep in their quest for scientific data? Are they particularly dedicated Park Service resource managers, willing to lose sleep to further their research goals? Or are they a group of lean and hungry grad students, willing to do almost anything to get data for their graduate-level research?

Neither one. These folks are volunteers, giving up comfort and sleep to advance the goals of science in the field and in the classroom and loving every minute of it! This summer, 16 teacher-volunteers spent two weeks laying transects, trapping small mammals, listening to bird songs, counting nests, and collecting plant species, all in an effort to inventory the offshore islands of Acadia National Park. The volunteers contributed 1100 hours of their time and provided Acadia with a large amount of resource information, including information on species of special concern to park managers. And as soon as these energetic teachers got home, they proceeded to apply what they'd learned, stimulating the minds of hundreds of students and introducing them to the excitement and challenge of science and to the vital importance of preserving natural resources.

"This is one of the most rewarding experiences with volunteers that we have had at Acadia," says Judy Hazen-Connery, who is a resource management specialist at Acadia and coordinated this inventory project. "The teachers were enthusiastic and hard-working. The group completed a number of labor-intensive tasks in a fraction of the time it would have taken a smaller research team. Our information on the small, off-shore islands of the park was limited. The data gathered in this summer's project has already given us a clearer picture of the biological resources on the islands, and some of this information will be used immediately to develop protection plans for sensitive species we discovered."

These teacher-volunteers went to Acadia as part of "Expedition into America," a National Park Service project designed to allow volunteers to help conduct biological inventories in national parks. "Expedition into America" is part of the Servicewide Inventory and Monitoring Program.



Jan Collins, left, and Debra Swartzendruber bait small mammal live traps with a sunflower seed, oatmeal, and peanut butter mix.



Park staff teaches volunteers how to run transects for live-trapping small mammals. (Photo by Debra Schwartzendruber, Earthwatch volunteer teacher.)

The project evolved in response to the National Park Service's initiative to create complete biological inventories in the 250 national parks with significant natural resources. In cooperation with Earthwatch, a non-profit organization specializing in providing volunteers for scientific field research, 16 teachers were recruited, screened, trained, and sent to Acadia National Park.

Earthwatch handled recruitment and travel arrangements, as well as providing coordination guidance. (The National Park Service has an "umbrella" cooperative agreement with Earthwatch that allows any park to use their services.) The group of sixteen teachers was divided into two, more manageable, groups of eight, and each group spent two weeks in the field under the guidance of two principal investigators provided by the National Park Service.

Since the volunteers arrived with different levels of knowledge and skills, Acadia paid special attention to training. Stacks of pre-project reading materials were prepared and sent to each volunteer. Once in the park, the volunteers spent a full day learning basic flora and fauna identification and inventory techniques and how to use field guides, maps, and compasses. On-site training continued as needed throughout the duration of the project.

"We couldn't train everybody in all methods," explained Glen Mittelhauser, principal investigator of the project, "so we divided each group into four teams of two. Each team worked on one or two specific projects, such as bird identification or small mammal trapping and identification. We created detailed written instructions for the methods for each team's particular task. These smaller project-focused teams worked well."

Throughout the four weeks spent on three off-shore islands, the volunteers established permanent monitoring transects, created maps, identified flora and fauna, collected museum specimens, and created a photographic record of the perimeter of two islands. (See sidebar for more details.) The groups were better at some tasks than others. While quite capable of making voucher collections of plant species, identification proved frustrating and sometimes impossible. Amphibian identification was easy because only one species (red-back salamander) was present, but volunteers had problems recognizing some of the small mammal species they encountered. The volunteers proved most useful at non-technical, labor-intensive tasks, such as mapping, establishing transects, laying out traplines, photo-monitoring, and plant collection.

"If consideration is given to the strengths and weaknesses of a volunteer group in designing a biological inventory project, both the volunteers and the park can benefit greatly," says Judy Hazen Connery. "On this project, the added benefit of having teachers as volunteers made every effort on our part worthwhile. They were developing curricula on their lunch break and discussing ideas into the wee hours of the morning. Our investment of time in 16 teachers will continue to increase geometrically, instilling a conservation ethic into hundreds of students around the country."

According to Earthwatch, who received follow-up reports two months into the school year, the nine teachers responding had already made 55 presentations in the classroom, reaching over 960 students. Four teachers made presentations at the Maine Science Teachers Conference in Portland, Maine, as well as in their local communities, reaching over 264 people. Plans have already been made to present at five more teacher conferences during the school year. And that's just this year. These teachers will continue to share their experience with students for as long as they teach.

In addition to filing a report, Earthwatch requires participating teachers to submit lesson plans derived from their field experience. The responses have been remarkably creative. One teacher in Mississippi recreated the entire inventory project in her large backyard, running a comparative species diversity study in pine and hardwood forests for 7th- and 8th-grade students. Another class is conducting comparative in-depth profiles of several local habitats in Maine; the project includes an environmental assessment and discussion of the ethics of conservation. Other teachers have arranged for their students to exchange and compare data for different sites within Maine and across the country.

The teachers' evaluations of the project were unequivocally enthusiastic. While most of the participating teachers had some scientific background, few had participated in field studies. Almost every teacher felt that their field experience in Acadia made science more "personal" to them, immediately increasing their ability to involve their students in scientific research. One hundred percent of the responding teachers said that they would be better able to address environmental concerns in the classroom. As John Monten, a high school teacher in New York, pointed out, "...[having] their teacher...actively involved in environmental and conservation issues is a great example to the students and the educational community."

"Expedition into America" will return to Acadia next year. Effort is being made to recruit some of the teachers who participated in this year's project, which will cut down on training time and increase the teams' efficiency. Six other parks are also participating in the project in 1993: Big Bend National Park, Cumberland Island National Seashore, Golden Gate National Recreation Area, Mammoth Cave National Park, Oregon Caves National Monument, and Shenandoah National Park. If these pilot projects prove successful, and funding remains intact, "Expedition into America" volunteers may provide an efficient, cost-effective way to complete the less technical aspects of biological inventories throughout the National Park Service.

(Funding for the 1992 project was provided by the Inventory and Monitoring Program, Parks as Classrooms, the Wildlife and Vegetation Division, the North Atlantic Region Science Office, and Acadia National Park.)

Acadia Research Highlights

By Glen Mittelhauser, Biological Technician, Judy Hazen Connery, Resource Management Specialist, and Jamien Jacobs, Biological Technician, Acadia National Park

Acadia National Park preserves approximately 41,000 acres in Maine, with land on the mainland as well as on Mt. Desert Island, Isle of Haut, and twelve smaller islands scattered along the coast. Although much is know of Mt. Desert Island's resources, due to limited staff time and resources, basic inventories of flora and fauna, including species lists, have never been initiated for the smaller offshore islands of the park. Due to their physiography and unique habitats, these islands may harbor species and habitats of special concern to management. In addition, the development of baseline resource inventories is the first step in producing strategies for long-term monitoring and protection.

Of the twelve park-owned islands evaluated for inclusion in this inventory project, three were selected for the initial effort. Pond Island was chosen because little was known about its resources, it was of a manageable size, and are accessible by row boat. Baker Island was selected because park managers need specific ecological information to address pressing management issues. Schoodic Island, the third island included in the project, was only recently acquired by the National Park Service, and we have little information on it. This island harbors significant seabird nesting colonies and is a Maine critical area for common eider and bald eagles. Failure of nesting bald eagles to produce young this year made it possible for teams to work on Schoodic Island without disturbing the eagles. The following list gives an overview of what we found on the islands.

Schoodic Island, 27 hectares

- No resident mammals (616 trap nights).
- Red-backed salamander and garter snake populations documented.
- 15 nesting bird species, including federally endangered bald eagle
- 139 species of vascular plants identified, including state-listed beachhead iris and two locally rare species.
- 18 permanent photopoints established.

Pond Island, 6 hectares

- 3 resident mammals documented (220 trapnights):
  - Boreal redbacked vole
  - Red squirrel
  - Masked shrew
- No reptiles or amphibians captured.
- 101 vascular plant species identified, including state-listed beachhead iris and two locally rare species.
- 27 bird species observed.
- 12 permanent photopoints established.

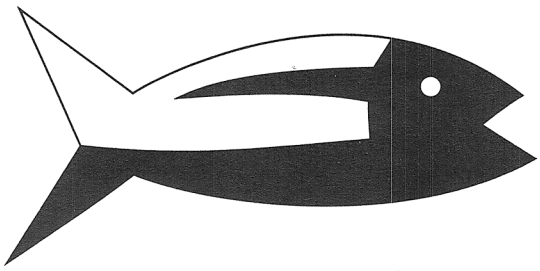
Baker Island, 66 hectares

- 3 resident mammals documented (240 trap nights):
  - White-tail deer
  - Meadow vole
  - Mink
- Red-back salamander and garter snake populations documented.

Restoring and Managing Park Fisheries

By Frank M. Panek, Fisheries Program Manager, Wildlife and Vegetation Division

The national parks support some of the nation's most splendid and diverse aquatic habitats and fisheries resources. This splendor extends from the Alaskan rivers of the Noatak River National Preserve with their abundant Dolly Varden and arctic char fisheries to Virgin Islands National Park, where angelfish and butterfish live among the reefs. In addition to supporting world-famous fisheries for cutthroat trout at Yellowstone National Park and striped bass at Cape Hatteras National Seashore, the national parks also support lesser known but equally important fish such as the Devils Hole pupfish at Death Valley National Monument, the colorful garibaldi of Channel Islands National Park, and the rarely seen smoky madtom of Great Smoky Mountains National Park. Aquatic and fisheries resources are important components of 153 park units.



1 Protect, restore, and conserve fishery resources.

2 Increase the quality, quantity, and diversity of recreational fishing opportunities.

3 Improve partnerships between governments and the private sector for conserving and managing recreational fisheries.

4 Identify and incorporate economic values and opportunities in developing recreational fisheries programs.

National parks provide unique opportunities to view migratory salmon or coral reef fish, to learn about fishing as a part of our cultural heritage, and to educate the public about environmental ethics. In addition, many national parks provide spectacular and aesthetically rewarding fishing experiences. Park fisheries programs emphasize the role of fish in natural ecological processes and provide closely regulated recreational fishing opportunities for native fish in natural habitats. The preservation of habitats, species diversity, and ecological functions are paramount to the Park Service's fisheries program.

In 1988, the National Park Service, along with more than 60 other federal, state, and private organizations, signed the National Recreational Fisheries Policy. This policy provides broad, long-term goals for the conservation of the nation's fisheries resources. Using this policy as an umbrella, in 1992 the National Park Service developed its own recreational fisheries program, called "A Heritage of Fishing."

"A Heritage of Fishing" provides a comprehensive guide for the development of the Park Service's fisheries program. Under the guiding mission of the Organic Act of 1916, the recreational fisheries program is dedicated to preserving and restoring aquatic ecosystems and improving recreational fisheries management. Four major goals drive the program. (See box.)

Significant progress was made in 1992 towards achieving some of these goals. For example, work has continued on restoring native brook trout populations in Great Smoky Mountains National Park and bull trout at Crater Lake National Park. Inventory and management of cutthroat trout populations at Glacier and Yellowstone national parks, and evaluation of new fishing regulations at Olympic National Park also continued. Significant efforts to recover the Colorado squawfish and other endangered fish in the Colorado basin were initiated by Park Service fishery biologists.

In May 1992, the National Park Service, along with the Forest Service, Fish & Wildlife Service, Bureau of Land Management, and Bureau of Reclamation, signed a Memorandum of Understanding (MOU) with Berkley, Inc., and the In-Fisherman, Inc. This MOU provides a framework for cooperative projects with these fisheries-industry businesses to advance "resource conservation programs, public awareness of fishing knowledge, angler skills and social benefits, angler ethics, and good stewardship of fisheries resources on public lands and waters." A key element of this program was the publication of "Pathway to Fishing." "Pathway" is an educational, walk-through seminar designed for children and adults.

Park rangers and natural resource staff in 14 units provided activities and interpretive programs reaching over 10,000 park visitors during the 1992 National Fishing Week. In 1993, National Fishing Week will include the establishment of new partnerships with other federal, state, and local conservation organizations.

Despite the fact that considerable efforts have been made to conserve and manage park fishery resources, many challenges remain unmet. In December 1992, the Park Service completed an assessment of its fisheries program needs. The Fisheries Needs Assessment and Action Plan provides a strategy for enhancing the National Park Service's program of basic fisheries research, inventory and monitoring of resources, evaluations of management options, and requirements for the rehabilitation and construction of docks, piers, and boat ramps supporting recreational fishing activities.

Updates and Briefs

President Signs Grand Canyon Protection Act

On October 30, 1992, the President signed into law the Grand Canyon Protection Act as part of the Reclamation Projects Act of 1992. The Act requires the Secretary of the Interior to operate Glen Canyon Dam in such a manner as to "...improve the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established...." The Act requires that the environmental impact statement (EIS) on the operation of Glen Canyon Dam, currently being prepared by the Bureau of Reclamation in cooperation with the National Park Service and other agencies, be completed within two years. It also requires that the dam be operated according to the interim flow prescription implemented in 1991 until a decision regarding final operations is made following completion of the EIS. Any changes in interim operations will require consultation with cooperating interests (including the National Park Service). The Act authorizes a long-term program of monitoring and research to evaluate river resource response to operations decisions.

Ag Interests Fight Water Quality Protection

A federal lawsuit to require the Florida Department of Environmental Regulation and the South Florida Water Management District to protect water quality in the Lake Okeechobee-Everglades ecosystem was settled in 1991. The settlement agreement requires construction of 35,000 acres of wetlands to treat phosphorous and nitrates from agricultural runoff. The agreement also contains performance-based water quality standards, gives the state a timetable for meeting those standards, and provides for continued court jurisdiction to enforce the agreement. Agriculture interests have taken legal action in 1992 to challenge the legal and technical basis of the agreement and to block its implementation. In spite of an administrative hearing process which includes 129 expert and over 200 fact witnesses, the implementation schedule for the agreement has remained on track in 1992.

Southern Appalachian Mountain Initiative Launched

The Department of the Interior announced during 1992 that sensitive resources at Great Smoky Mountains National Park were experiencing adverse impacts from air pollution and that new major sources of pollution proposed for the vicinity would likely contribute to the impacts. Consistent with the approach identified in 1991 for Shenandoah National Park, the Department recommended that the states in the region not issue permits for major new sources of air pollution unless measures are taken to ensure that the new sources are benign to park resources. A conference attended by over 150 people was held in Gatlinburg, Tennessee, to address the regional nature of the air pollution problems at Great Smoky Mountains and Shenandoah national parks. Represented were industry, state and federal agencies, academia, and the public. The conference examined the scientific understanding of air pollution in the Southern Appalachians, as well as ideas for addressing the problem.

In response to the controversy over new source permits and the discussions at the Gatlinburg conference, the Environmental Protection Agency, nine southeastern states, the National Park Service, and the U.S. Forest Service met in June to launch the Southern Appalachian Mountain Initiative. Its mandate is to develop mutually agreeable regional solutions to the identified air pollution problems. The Initiative has the opportunity to consider *all* air pollution sources in the region, to examine what various Clean Air Act programs can do for Class I air quality protection, and to develop cost-effective, innovative ways to reduce air pollution levels in the Southern Appalachians.

Crater Lake Thermal Features Proven Significant

After completing research at Crater Lake National Park, the National Park Service concluded in a report to Congress that the hydrothermal features discovered at the bottom of Crater Lake are significant. Park thermal features qualifying as "significant" under the Geothermal Steam Act Amendment of 1988 are protected by special measures if federal geothermal resources adjacent to the park are under leasing consideration. For example, leasing may not proceed if development of adjacent geothermal resources are found to result in significant adverse impacts to park resources.

The two-part Park Service report includes a review of the large body of research performed by investigators from Oregon State University, the National Park Service, the U.S. Geological Survey, and other institutions concerning the presence of thermal water inflows into Crater Lake. Pertinent topics assessed include the formation of Crater Lake, the hydrologic and chemical balances for the lake as a well-mixed body of water, thermal and chemical characteristics of springs on the flanks of Mount Mazama, distribution of dissolved constituents as a function of depth, and submersible observations in the deep part of the lake. All studies support National Park Service findings that the hydrothermal inputs contribute to the properties of Crater Lake by affecting the lake's geochemical regimes and by influencing

the lake's mixing rates. As such, the thermal inflow is an important contributor to lake processes and water quality.

The report describes the size and extent of the hydrothermal features at the bottom of Crater Lake, which are defined by the areal distribution of fluid inflow at sites on the lake floor, the magnitude of the thermal water inflow, and the effect on the sites of fluid inflow on the entire lake (53 km^2). The areal extent of the sites of fluid inflow is indicated by large areas of bacterial mats and visually spectacular blue pools located in the south basin and off Palisade Point. The magnitude of the thermal water inflow is approximately 5% of the total inflow to the lake, and the dissolved constituents in the thermal waters dominate lake chemistry. The thermal fluids result in a convective heat flow which is the second largest of the 31 thermal spring systems in the U.S. portion of the Cascades.

The mixing processes at Crater Lake are driven by a combination of surface heat transfer and thermal input from the inflow of thermal water from the lake bottom and are scientifically and geologically important among deep, temperate lakes of the world. The inflow of thermal water has a direct effect on the density structure of the deep lake and affects the rate of heat transport and distribution of lake constituents. Also, the studies conducted and techniques used to describe these thermal features contribute to the scientific understanding of deep lake processes.



Crater Lake



GIS Goes Regional

RTSCs: A Key Link in the Implementation of Servicewide GIS Technology

By Gary S. Waggoner, Chief Policy and Planning Branch, GIS Division

We live in an age of information. Information is most effectively used in critical decision-making situations. The power of information is significantly enhanced when data are useable, accurate, displayable, integrated, and accessible in a timely fashion. Geographic information system (GIS) technology is an important tool in meeting this criteria and empowering managers with information.

While GIS is a tool, it is more like an electron microscope than a magnifying lens. To use the tool to its fullest advantage, the user must be highly trained and have good technical support. As with all computer software, GIS software can analyze any quality of properly formatted data in any fashion that the user desires. However, the old adage of "garbage in, garbage out" can certainly still apply. To make matters worse, GIS technology advances as rapidly as audiovisual equipment in the consumer world. In both technologies, significant improvements become available every few months or so, making it extremely difficult for the average user to keep abreast of meaningful advancements. This is particularly true in the Park Service because the user often is already inundated with other important responsibilities and activities.

GIS technology advances as rapidly as audiovisual equipment in the consumer world. In both technologies, significant improvements become available often, making it extremely difficult for the average user to keep abreast of advancements.

Regional Technical Support Centers (RTSCs) have been identified as a critical link that will enable the National Park Service to fully implement GIS technology Servicewide. The Park Service has experienced explosive growth in the use of GIS technology for managing parks. The Park Service's GIS Division can no longer adequately respond to the huge volume of requests for technical support from the field in the areas of data base development, hardware and software support and installation, training, preparing park GIS plans, and comprehensive application development. As a result, regional GIS coordinators working with the GIS Division have developed a strategy of establishing at least one Regional Technical Support Center in each region to provide the necessary support to the field.

To reflect the different types of parks making up regions, RTSCs will have a different flavor in each region; but all will have the same basic responsibilities. RTSCs will be located at universities (cooperative park study units) or at regional offices. More specific technical support will also be provided by the GIS Division, various Washington Office program offices such as the GIS Lab with the Interagency Resources Division, and the Water Resources Division. In addition, larger parks will serve the GIS needs of smaller parks in a node and cluster concept.

These RTSCs will be able to 1) assist parks in developing GIS plans; 2) develop GIS data bases; 3) document and archive data bases; 4) conduct applications; 5) provide technical support on hardware and software; 6) do hardware and software installations; and 7) provide GIS training. They will provide the high degree of professionalism and competency necessary to assist parks in "staying on top of" the ever-changing, high-tech GIS field. While each RTSC principally serves the needs of parks in one region, it is possible that RTSCs will eventually specialize and provide specific support to a broader cadre of parks. In the future, more RTSCs may be established to provide park support in highly specialized fields, such as hazardous waste analysis, threatened and endangered species habitat analysis, or in coastal ecosystem parks. University-based RTSCs, while minimally staffed, will be able to draw on the availability of university faculty and students to help National Park System units implement GIS.

The regional distribution of RTSCs will provide better support to parks because of a more informed understanding of the regional environment. The GIS Division will develop Servicewide GIS policy, standards, and guidelines, as well as test and evaluate GIS software and hardware and develop specialized GIS applications with Servicewide implications. Through these functions, the GIS Division will coordinate and support the RTSCs. Park Service cooperation and coordination among the burgeoning number of agencies and organizations involved in GIS will also be the purview of the GIS Division.

While there are currently 10 RTSCs in existence, they are not yet adequately funded and staffed to be fully operational. Nonetheless, these centers are doing everything they can with extremely limited resources to assist parks in their efforts to use GISs in the decision-making process.



GIS Aids Boundary Planners

By Bill Conrod, Resource Management Specialist, Niobrara/Missouri National Scenic Riverways

With the signing of the "Niobrara Scenic River Designation Act of 1991," the National Park Service took the lead in developing five plans to shape use along 200 miles of the Niobrara and Missouri rivers in Nebraska and South Dakota. The planning process promises to be both complicated and controversial. The National Park Service hopes to facilitate plan development by using a geographic information system (GIS) to analyze all the variables involved.

The area along the Niobrara and Missouri rivers is a region of transition between the humid east and the arid west. Tallgrass and riparian oak woodland gives way to sandhills of mixed grass and ponderosa pine. The spring-watered Niobrara valley also provides cool conditions that have retained ice-age plants, such as paper birch and aspen, now isolated far from their usual range. The rivers cutting across the plains not only provide for modern recreation, but were also used as historic and prehistoric travel corridors.

The designation act added two new river segments to the National Wild and Scenic River System: a 70-mile stretch of the Niobrara River in northern Nebraska, designated scenic, and a 39-mile stretch of the Missouri River along the Nebraska-South Dakota state line, designated recreational. As a result of legislation, general management plans as well as special resource studies (previously known as new area studies) are underway for these areas.

In addition to protecting the free-flowing state of a river by preventing new federal water projects, Wild and Scenic River designation requires special plans for affected segments. The managing agency makes a plan to protect adjacent lands, generally within a quarter mile of the river, that have high natural, cultural, or scenic values. The plan must include boundaries and management alternatives for lands adjacent to the rivers in order to preserve the resources and landscapes.

This is where things get complicated. The adjacent lands are mostly privately-owned farms or ranches in an area where local values stress independence. The Congressional testimony and debate leading up the designation act spoke of a commitment to keeping ranches in operation and did not envision a large federal land acquisition program. In fact, the designation act limits land acquisition by condemnation along the Niobrara, as long as local governments are effective in protecting resources through zoning or other means.

The project is also very complex because of the number of ongoing management plans covering the 200-mile-long area. To help streamline this, the National Park Service is developing a computerized GIS. This project is a first for the Park Service to use GIS as a major analysis tool at the ground level of new unit planning, including determining boundaries and resource protection. Boundaries will certainly be controversial, and GIS offers a systematic, resource-driven approach that should be defensible.

A great deal of data from universities and agencies are being compiled for the GIS. A GIS provides the means to integrate many different types of mapping data, including topography, water features, plant cover type, endangered species, fossil sites, roads, buildings, cultural resource sites, known mineral resources, and political boundaries. This will improve planning efficiency by reducing production labor cost and increasing analysis quality. Graphics can be printed quickly or revised in a park office without spending a lot of time at the drawing board. Planners will be able to use predictive models for a more systematic approach, such as calling for maps showing side slopes visible from the river, areas of likely fossil or archeological sites, or areas of unusual species richness. Planners will be able to ask "what if" impact analysis questions, then produce mapped results. Centralizing map data also draws different professional disciplines together.

Determining boundaries and planning management strategies to protect resources on private lands along the rivers is a real challenge. This problem is compounded in the current climate of reduced options of direct federal action. We hope use of GIS for the first time by the National Park Service in ground floor boundary planning and impact analysis will streamline the process and add credibility to the plans and resource protection.

GIS Supports Natural and Cultural Resource Management in the Mid-Atlantic Region

By Hugh A. Devine, Mid-Atlantic GIS Technical Support Center, North Carolina State University

Mid-Atlantic Region's historical and natural parks have a wide variety of map data needs ranging from Revolutionary War archeological data to present-day locations of threatened wetlands. The Mid-Atlantic Region is initially providing geographical information system (GIS) support for its parks through several cooperative efforts with universities. The GIS Research Program at North Carolina State University is one of these units, and to date this group has focussed on GIS applications for the cultural/historical parks that dominate the Region.



Jamestown Church Tower in Colonial National Historical Park. GIS provides technical support for extensive archeological activities associated with the 400th anniversary of the Jamestown settlement.

Colonial National Historical Park in coastal Virginia is an excellent example of the potential for regional GIS support. The regional support program has been exceptionally productive at Colonial over the last three years. This support has ranged from assistance with the development of a GIS plan to instruction in how to construct effective maps. One of the major GIS activities at Colonial is the development of procedures to integrate cultural resource management activities with those of the natural resource management program. An example of this integration is wildfire suppression. Fires are handled by both the park and through cooperative agreements with fire departments

from the surrounding municipalities. Communication with these departments regarding appropriate fire suppression strategies in areas with significant cultural and natural features has long been a major problem (e.g., construction of fire lines across earthworks). The GIS was used to locate all important cultural features and to produce "values at risk" maps that were distributed to the fire companies. These maps identify not only the natural and cultural resources to be protected, but clearly indicate what suppression strategies are to be employed.

One of the truly unique activities of the support center at Colonial was the cooperative effort with the Park Service's GIS Division in training and placing a minority student intern in the Colonial GIS office. The student, who was from a historically black university, started the first summer with a one-week training program at North Carolina State, and then spent the rest of that summer (1991) and all of the next working at Colonial. Research is now underway to develop GIS training programs for minority campuses from the support university that can be delivered via inexpensive telecommunication networks.

Another unusual application of GIS is occurring at the Jamestown Island unit of the park. Extensive archeological activity is currently underway in preparation for the settlement's 400th anniversary in 2007. A separate GIS workstation has been placed on-site at the island with electonic access to all previous excavation maps and data. This same station is also used to record all new finds and to directly enter them into the park's GIS. The base map for this cultural effort (roads, present and historic vegetation, shorelines, etc.) was developed as part of the natural resource program for vegetation and wildlife management.

Regional GIS Technical Support Center Assists Users in the Midwest Region

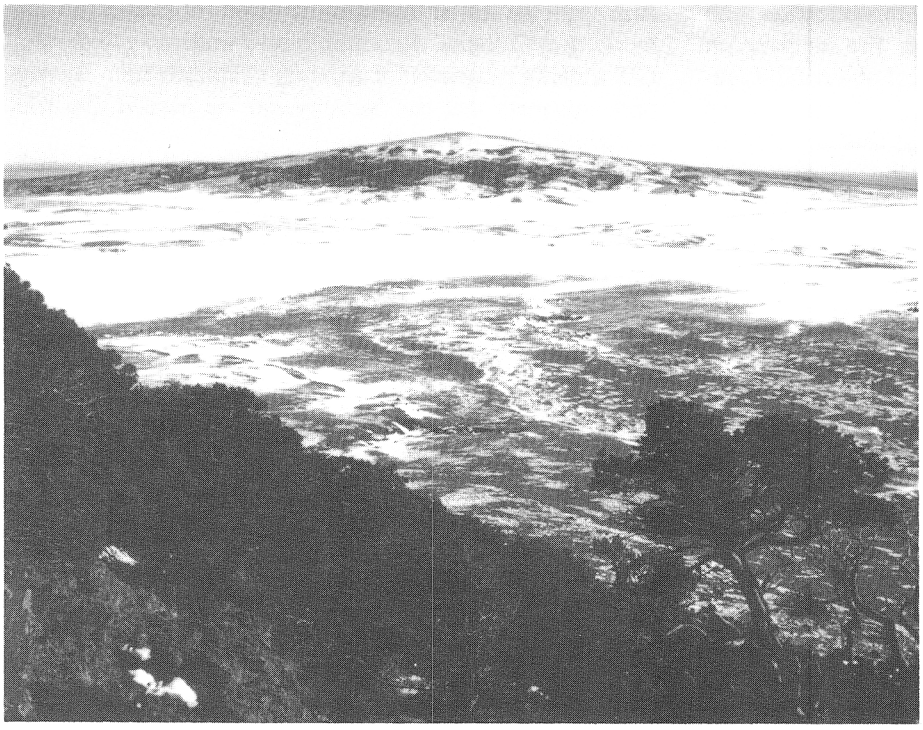
Steve Cinnamon, Chief, Resource Management Branch, Division of Natural Resources, Midwest Region, and Joe Meyer, GIS Coordinator, University of Wisconsin-Madison, Technical Support Center

The growth of geographic information system (GIS) technology in the Midwest Region has been steady during the last decade. GIS activities designed to support park management and operations are in place or under development in many parks in the region. The approach in the Midwest Region has been to support data development with project funds, primarily through the Natural Resources Directorate and the Natural Resources Preservation Program. The Midwest Region's GIS program is also partially supported by the Global Climate Change Program; midwestern parks' global change research will be a major "client" of regional GIS support. Currently, the Global Climate Change Program funds GIS operators at Voyageurs and Isle Royale national parks, in addition to a position at the Ozark Highlands site.

In FY92, the region received base funding for a GIS coordinator, thus beginning an era of continuity in the Midwest Region's GIS effort. A GIS steering committee, formed in FY90 and composed primarily of GIS specialists and park superintendents, met in February 1992 to rate competitive proposals submitted by two universities for the location of the Midwest Region's GIS Technical Support Center. The University of Wisconsin at Madison was selected due to its leadership in the GIS field (including associated disciplines of geography, remote sensing, conservation biology, forestry, etc.), the ability to provide office space and support, and access to GIS facilities. The full-time GIS coordinator, who arrived in Madison in November, is expected to spur GIS activity at the parks by providing assistance, guidance, and expertise. In addition, the Great Lakes Cooperative Parks Study Unit is located at the University and will provide administrative support. Initially, the coordinator will be the only Park Service person stationed at the Center, working with University personnel associated with the Center.

There are many advantages to locating the Center at a university, but there are also pitfalls to avoid. Foremost among the pitfalls is the isolation from parks, the regional office, and program offices. The primary mission of the Center is to provide support to parks and program offices, and the Center will be sensitive to its constituency.

The relationship between the Center and the University of Wisconsin will be one of mutual cooperation and benefit. The benefit to the University will be increased opportunities for professors and researchers to study national parks and their resources. Students will also be encouraged to study National Park Service resources and gain hands-on experience with park projects. For example, during the 1992 fall semester, Dr. Steve Ventura directed a graduate course practicum toward the needs of the Ice Age Trail office. The Center will also increase the visibility and ambassadorship of the National Park Service on campus.



Information gained from the inventory of the geological features of Capulin Volcano will be used to protect this recently extinct volcano.

Volcano Study Conducted at Capulin

By Geoffrey Smith, Resource Management Specialist, Capulin Volcano National Monument

Capulin Volcano National Monument is a small park area located in the Raton-Clayton volcanic fields of Northeastern New Mexico. It was withdrawn from settlement, entry, or other disposition under any public land law in 1891 and designated a national monument in 1916 by President Woodrow Wilson. Presidential Proclamation No. 1340 stated that creation of the monument was to preserve "...a striking example of recent extinct volcanos..." which are "...of great scientific and especially geologic interest..."

As yet no major geologic study has been completed at Capulin. That is about to change. Late in 1992, the Southwest Regional Office and Capulin Volcano National Monument entered into a cooperative agreement with the College of Santa Fe to complete such a study. The primary goals of the study will be to map, age, and determine the chemical composition of the lava flows and related geologic features in and around the monument. Rock samples will be collected, including 1" rock corings, to provide specimens for geochemical work and paleomagnetic analysis, and to provide large examples, thin sections, and photographs of each distinct rock type for National Park Service collections and interpretive displays. Organic material also will be collected and radiocarbon dated to attempt to correlate volcanic events with the activities of Folsom Man.

The specific objectives of mapping will be to analyze and locate all distinct volcanic strata and features, including ash and cinders, lava flows, lava tubes, pressure ridges, squeeze-ups, plugs, dikes, vents, flow directions, and any other interesting geologic phenomena. Global positioning devices will be used to prepare accurate geo-referenced maps utilizing a geographic information system (GIS). Mapping will also be used to help establish the geologic history of the rock and sediment layers (stratigraphy) and to determine if the Folsom Man site a few miles from the monument's northwest boundary can be correlated stratigraphically with Capulin Volcano. The final product will be published and made available to geologists and the general public. Much of the park staff will be involved in the mapping and other field research activities.

At the end of this study, which is due to be completed in 1994, the accurate account of Capulin Volcano and its relationship with the surrounding landscape and global geologic processes will at last be known. Baseline data of this nature is critical in helping to protect the resources specified by Capulin's enabling legislation. And the translation of this scientific data to interpretative information will give the public a richer opportunity to relate to this fascinating series of geological events.



Bending the Boundaries of Cultural and Natural Resource Management

Minute Man's Historic Landscape Restored

By Nigel Shaw, GIS Specialist, North Atlantic Region Office of Scientific Studies,
and Dan Dattilio, Chief Ranger, Minute Man National Historical Park

Geographic information system applications (GIS) in the North Atlantic Region support numerous projects in national parks, including restoration of an 18th-century Revolutionary War period landscape with working farms, analyzing animal behavior, controlling fire danger, protecting genetic stock of historic plants, and figuring out what life was like for prehistoric people.

The Revolutionary War era landscape project at Minute Man National Historical Park (NHP) focuses on both cultural and natural landscapes. The GIS component of the project was proposed by the North Atlantic Region's Cultural Resources Office, which is funding the project. Regional Technical Support Center (RTSC) staff at the North Atlantic regional office assembled the digital database from a variety of hard copy and digital sources. The application is being developed and executed at the University of Massachusetts, Amherst, Department of Landscape Architecture and Regional Planning, with technical oversight and assistance from the RTSC.

In this project, GIS is used to identify where new working farms can be most appropriately located to recreate the colonial landscape. The farmers west of Boston, who formed a local militia called the Minute Men, were the men Paul Revere sought to warn of approaching British troops when he set out on his midnight ride on April 19, 1776. These farmers stockpiled guns and ammunition against British orders, engaging the British troops in the first battle of the Revolutionary War. The Minute Men won the battle and demonstrated for the first time the utility of guerrilla style warfare. How were they able to do this? In large part because of their knowledge of the lay of land. The Minute Men knew what to scout, where to hide, when to ambush, and how far to the next overlook.

Since 1776 this critical configuration of land uses and local relief has been obscured as houses and businesses were built, farmland was changed or abandoned, and forests began to grow back. The project seeks to bring back to life the scene of the battle, illustrate the role local geography played in it, and bring that experience to park visitors. The plan is to reestablish the historic landscape by reintroducing working farms. GIS maps of soils, current land cover, and available housing are analyzed to indicate where these farms are economically viable, what crops will support them, and how much acreage is needed. GIS maps showing colonial land use patterns, areas most visible and accessible to visitors, and sites with particular historic significance in the battle are analyzed to show what farming practices will be historically appropriate in different places and to prioritize by location.

In addition to considering economics and historical suitability in establishing these farms, GIS allows park managers to incorporate considerations such as protecting sensitive ecological areas, connecting the park trails to regional trail systems, and screening modern land uses from sight.

Altogether, the GIS analyses make possible a more robust and integrated approach to park planning and management. The net effect will be a significant change in the landscape at Minute Man NHP that enhances the visitor experience, contributes to the local economy, and protects park resources.



Managers in Minute Man National Hisorical Park rely on GIS technology to restore and maintain historic landscapes. This area around Hartwell Tavern will be cleared and restored to its 18th-century agricultural landscape.

Workers clear mangrove from Kaloko Pond in Kaloko-Honokohau National Historical Park. When left on their own, mangrove will overwhelm the native vegetation around the fishponds, destroying valuable wildlife habitat.



Mangrove Removal Restores Wildlife Habitat in an Ancient Hawaiian Fishpond

By Cynthia Kapuniai and Janet Zwicker, Resource Technicians,
Kaloko-Honokohau National Historical Park

Centuries ago, the ancient Hawaiians created coastal fishponds to supplement their food supply. Two such ponds are located within Kaloko-Honokohau National Historical Park, Kailua-Kona, Hawai'i, the site of an early major settlement. These areas currently serve as habitat for rare and endangered waterbirds, such as the Hawaiian stilt and coot.

The introduction of the exotic species red mangrove to the Hawaiian Islands posed a major threat to these 7-10 acre ponds. Within a decade, this rapidly-growing tree with its abundant water-born seeds had formed dense thickets up to 30' in height. These thickets surrounded the fishponds. The natural balance of the ponds was threatened by decaying mangrove and the numerous prop roots, which encouraged siltation and damaged archeological sites. Waterbirds were also displaced as breeding and nesting habitat decreased.

Park personnel and the Cooperative Park Study Unit at the University of Hawai'i at Manoa took action to research, eradicate, and control the invading mangrove. A primary goal of the project was to develop a cost-effective, environmentally-acceptable technique to control and remove red mangrove from the park. When developing and implementing the management program, consideration was given to techniques that avoided further degradation of the park's natural and cultural resources. Heavy equipment, herbicides, and burning could not be used because they created undesirable impacts. Sample areas were tested and evaluated to determine a control strategy.

The most effective plan appeared to be the most labor intensive and included cutting the mangrove with chainsaws, loading the harvested trees onto a boat, and hauling them to a central location for chipping. In areas inaccessible by boat, mangrove was bundled and sling-loaded to the chipper site by helicopter. Developing seedings and regrowth were burned with a propane torch or pulled by hand and discarded. This has become an ongoing process as seeds continue to arrive from areas outside of the park.

During the experimental phases, initiated in 1988 and continuing through 1991, one to three employees worked on-site. During this period approximately 3 acres were cleared of mangrove. Because of the rapid growth rate of mangrove, park staff soon realized that immediate control was imperative, a task that at first seemed insurmountable. An all-out effort was initiated that included tripling the staffing level. In 1992, nine resource technicians were hired for eight months to harvest the remaining ten acres. The crew worked well together, sharing a common determination to see the mission accomplished. The acquisition of proper equipment increased the efficiency of the operation, resulting in completion in half the allotted time.

After removing red mangrove, the park initiated resource management projects designed to encourage the return and nesting of endangered water birds within these reclaimed lands. Early efforts appear to be very promising, giving unique natural resources in Hawai'i a chance to survive.



At John Muir National Historic Site, integrated pest management principles help keep the historic plantings healthy and attractive.

John Muir and the Wasps

By Herbert C. Thurman, Chief of Maintenance,
John Muir National Historic Site

The John Muir National Historic Site covers 334 acres that once were part of the fruit ranch owned and managed by John Muir and his family. Located in Martinez, California, 20 miles east of San Francisco, the site enjoys a Mediterranean climate--dry eight months of the year with rain from December through March. Visitors come to see and enjoy the Muir house, an Italianate 17-room Victorian mansion built in 1882, and the surrounding historic plantings. Fruit and nut trees representing those varieties grown by Muir have been planted on the 8 acres adjacent to the house. The home and landscaping reflect the general appearance of the area during Muir's residency (1890-1914) and communicate impressions of Muir as a family man, rancher, author, and conservationist.

In keeping with the policies of the National Park Service and the image of Muir as a friend of nature, the park uses integrated pest management (IPM) principles in caring for the site's landscape. IPM involves the use of non-chemical plant and insect pest management strategies, with chemical pesticides used as a last resort. Non-chemical strategies include traps, barriers, hand-picking of pests, or just a blast of plain water. Releasing beneficial insects called predators or parasitoids and using horticultural oils and soaps are also IPM methods.

To implement IPM methods, we must identify the specific pest by monitoring the affected plants. We then establish thresholds or levels of injury by determining when the pest population reaches the point of possible intolerable injury to the landscape. This injury can be economic, resulting in the loss of plants or crops, or aesthetic, resulting in poor-looking plants that reflect a lack of care. When defining injury we realize that organic horticulture requires us to accept some minor or reasonable damage to our landscape due to pests. IPM will not completely eliminate insect and other pests. It will, however, establish a balance between pest and predator. Once we establish when to take action, we then consider management alternatives that would be the least hazardous and disruptive to the environment.

In 1990, several varieties of ornamental and orchard trees at John Muir were seriously infested with whitefly by midsummer. The lemon, pomegranate, and hawthorn were covered with the pests, which suck the plant fluids on the underside of the leaves, causing them to curl, yellow, and in some cases drop. We identified the insect as the ash whitefly and determined that an intolerable damage level, both economical and aesthetic, had been reached. We researched the *University of California's Pest Management Guidelines* and noted that management recommendations were not available at the time but that on some crops white flies could be

reduced by small wasp parasites and predators, including big-eyed bugs and lacewings. The guidelines also stated that three to four applications of insecticides such as acephate suppressed infestations on other crops, but that effective long-term control had not been achieved. National Park Service policy required us to explore non-chemical solutions first. The acephate insecticide would be used only as a last resort. If non-chemical methods were of little effect, only then would we consider using chemical insecticides.

In earlier growing seasons, the park had already purchased and planted green lacewing eggs and parisitoid wasps. We expected these insects to suppress the ash whitefly, but they did not, probably due to the overwhelming number of pests. We had applied insecticidal soap to the affected foliage, but the "clouds" of insects merely flew to another tree, rendering this mild insecticide ineffective.

Having exhausted the non-chemical control suggestions mentioned in the *Pest Management Guidelines*, we contacted the University of California, Davis, to determine if they had a new management strategy for ash whitefly. They had--the encarsia formosa wasp parasitoid. This parasitoid lays eggs within the body of the pest; as the egg develops it eventually kills the hosts. The University was raising these beneficial insects for use by the University and the City of Davis. We were able to obtain approximately 2000 adult encarsia wasps. These were placed in the limb crotch of the afflicted trees. One week later an inspection of the ash whitefly egg population showed that 50-75% of their eggs had been parasitized by the wasp.

Biological control of the pest has been achieved at the John Muir National Historic Site. The ash whitefly population was not eliminated, nor do we expect it to be. However, the damage inflicted by the remaining pest population is below our threshold of unacceptable aesthetic and economic injury. Early next season we will resume monitoring to see if the wasp has overwintered and if the ash whitefly population remains within acceptable limits.

Morristown Managers Identify Exotic Species in Historic Landscapes

By Robert Masson, Biologist, Morristown National Historical Park

Morristown National Historical Park commemorates the main encampments of the Continental Army during two critical winters of the Revolutionary War. Approximately 600 acres of woodlands were cut down to create a "log-house city," sheltering some 10,000 American troops. From an ecological point of view, this historically important event provided the first instance of a major disturbance in the native forest cover. After the soldiers left, the lands within what is now Morristown National Historical Park underwent additional changes. Farming kept the most suitable land in cultivation, while the hillsides reverted back to forests.

The present landscape of Morristown National Historical Park is a reflection of its historical significance, varied land uses, and current management issues. Preserving the encampment site is an important management objective for the park. To manage the resources effectively, we need information. We already have detailed information on the history of the forests of the park. We are currently conducting a study of exotic species to obtain a greater understanding of the current changes taking place in the park's ecosystem due to a rapid increase in the range of exotic species.

Settlement and farming activities in the park area introduced many exotic plant species into the area, several through use as ornamental hedgerows. One particular species, Japanese barberry, has spread rapidly through many areas of the park in recent years. During the summer of 1992, a quantitative survey of the park was undertaken to determine the spatial extent of barberry. Transects and sampling points were established throughout the park and data detailing canopy composition, shrub stem and woody plant seedlings, and total herbaceous cover were collected. This information will provide a comprehensive assessment of the abundance of barberry relative to other understory plants and canopy composition. Analysis of these data will be used to establish permanent vegetation plots to be located in areas representative of the major canopy types and representative of the current range of barberry.

Dispersal of seeds (berries) by birds is thought to be a major factor in the spread of barberry. As the density of barberry increases, bird utilization may also increase, providing a geometric factor in the further spread of this species. This study will attempt to test this hypothesis, providing information on the most promising areas for control efforts. Control measures to be evaluated include flush cutting, removal of subsequent sprouts at periodic intervals, and selective application of herbicides.

Another exotic species, an annual grass called Japanese wiregrass, has formed a dense carpet throughout many areas of the park. One control measure that will be tested will be the use of partially composted leaves to prevent seed set and regrowth of plants. The areas will be surveyed for recurrence of plants and amount of remaining compost.



ResourceManagement: Hi-tech and Multi-faceted

Managing Smoke in Yosemite Valley

By Deb Pfenninger, Air Quality Specialist, and Bob Howard, Chief, Planning, Compliance, and Physical Science Branch, Yosemite National Park

For the visitors who camp in Yosemite Valley, an evening campfire traditionally ends the day. With over 800 campsites and 280 housekeeping units, this means a lot of campfires burn in the Valley every summer evening. The campfire smoke generated stagnates in the generally windless night air. Smoke from any surrounding wild or prescribed fires also is transported to the Valley by the night mountain air, which sinks as it cools. Yosemite park managers balance the visitors' desire for an evening campfire and the requirements for natural resource management through fire with the mandate to maintain the air quality of Yosemite National Park.

Smoke must be managed for a number of reasons. Burning wood produces an abundance of particulates. Particulates are non-gaseous air pollutants that, when equal to or smaller than 10 micrometers in size, become airborne and can be inhaled by humans and other animals. These small inhaled particles effectively bypass the body's defense mechanisms. The particles also settle out on plants, clogging their stomata and thus interfering with plant transpiration.

Visibility impairment is another problem caused by particulates. The California Clean Air Act and the Federal Clean Air Act both set standards for particulates. The state standard is 50 micrograms/meter^3 (ug/m^3) for a 24-hour average; the less stringent federal standard is 150 ug/m^3. Data from a HiVol particulate sampler located approximately 1 mile west of the campgrounds indicates that the park has violated state standards because of Yosemite Valley campfires. Night time particulate levels within campgrounds were thought to be considerably higher, although how high and for how long was not known.

Park management was concerned about the perceived high smoke levels. In 1989, the superintendent began to manage campfire smoke by prohibiting the collection of firewood in Yosemite Valley. Also, the park concessionaire began to sell dry wood and low emission logs for campers to use. Although particulate levels were still considered high in the east end of the valley, a significant decrease in the night time accumulation of smoke was observed.

To continue to reduce smoke levels, in 1992 the superintendent banned all morning and afternoon campfires from August 1 to October 31. In addition, all unattended evening campfires had to be extinguished prior to going to bed or leaving the campsite. Lastly, all campfires were restricted to dry wood only; no leaves, needles, pine cones, or wet or green wood. Law enforcement was limited to educational contacts in this first year.

Also in 1992, air quality and fire management staff rented a TEOM (Tapered Element Oscillating Microbalance) particulate sampler to better monitor the particulates generated by prescribed fires and campfires. This new technology has gained EPA certification, is reasonably portable, and gives a continuous readout of particulate levels. The HiVol sampler gives only a 24-hour average reading on a filter that takes two days to dry and weigh. The TEOM has the clear advantage of showing particulate levels in averages of ten minutes, thirty minutes, one hour, eight hours, and the state health-based standard of 24 hours.

The TEOM sampler provided data on the changing particulate levels every 1/2 hour and gave a 24-hour average. The sampler was run prior to and after the 1992 campfire restrictions, from July through October. This first year of monitoring provided the following information:

1. Except following precipitation events, 24-hour averages of PM-10 readings nightly approached or exceeded the state health standard before and after the restrictions, but did not exceed the federal standard.
2. Because the campers preference is to have an evening fire, the decision was made to allow these fires to continue even though it was known that the majority of the smoke would accumulate during the evening. As expected, particulate levels peaked nightly. Neither the lateness of the peak or the high particulate levels were anticipated. The particulate levels peaked after midnight and 1/2-hour averages on weekends commonly exceeded 250 ug/m^3.
3. Particulate levels were influenced by in-park wild and prescribed fires in drainages flowing into Yosemite Valley. Also, the sampler registered elevated levels because of wildfires outside Yosemite (over 50 miles away) during the dramatic fires in Calaveras and Tuolumne county.
4. Patrol rangers and campground hosts reported good compliance to the restrictions and favorable visitor response.

Although the particulate data are from Yosemite, the conclusions generated are probably not unique to the park; all campgrounds get smokey. Many visitors are becoming more cognizant and concerned about the degradation of the air they breath and the contribution they can make to help improve air quality.

After the data are analyzed, the decision will be made to implement the restrictions permanently or take other management actions. Other suggested options have included no-burn days, a campfire-free campground, or group campfire rings. It is hoped that this monitoring will allow closer management of particulate levels generated during prescribed fires, and balance campfire enjoyment with maintaining the air quality of Yosemite National Park.



As part of a systematic field survey of sea turtles in Texas inshore waters, a National Park Service researcher measures a captured green turtle.

Cooperative Study Provides Texas Turtle Management Information

By Donna Shaver, Research Biologist, Padre Island National Seashore

Abundant green sea turtle populations once supported a capture, slaughter, and processing industry during the late-1800's along the Texas coast. By 1900, turtle numbers had been decimated by overfishing and severe freezes. Today, all five sea turtle species that occur in Texas waters are federally listed as either threatened or endangered.

Until recently, little was known about the sea turtles currently inhabiting Texas waters. In June 1989, the National Park Service, in cooperation with the U.S. Fish and Wildlife Service and the Southwestern Parks and Monuments Association, undertook the first systematic field survey of sea turtles in Texas inshore waters. The primary sampling location selected for this research was the Mansfield Channel, located at the southern end of Padre Island National Seashore.

The Mansfield Channel is one of only three channels that provide a connection between the Gulf of Mexico and the Laguna Madre, a 125-mile-long hypersaline estuary. The Mansfield Channel jetty system is one of the few localities in Texas where concentrations of green turtles have been identified. Apparently, the Mansfield Channel is one of the most important inshore areas in Texas for green turtles. Green turtles probably use the area for both foraging and resting habitat, which is not available elsewhere in offshore Gulf of Mexico waters along the Texas coast. Migrating green turtles may stop at the Mansfield Channel jetties before they travel through the channel to access inshore feeding pastures within the Laguna Madre, after they exit inshore feeding pastures, or before they continue into offshore waters.

Unfortunately, when the turtles congregate at the Mansfield Channel, they become vulnerable to potential threats from fishing, boating, and dredging. Data collected through this study can be used to better protect sea turtles in this and similar habitats.

Beginning in June 1989, we netted turtles at the Mansfield Channel jetties on one day per month. We measured, weighed, photographed, examined, tagged, and released the captured turtles. Through these efforts, we were able to collect important information on the species composition, size classes, growth, seasonality, and residency of turtles at the jetties. From tag and capture data, we concluded that most turtles remained at the jetties for from a few days to a few months and then permanently left the jetty area. The data also suggest that although the turtles were present at the jetties during most months of the year, they left the area during periods of cold temperatures.

The number of turtles captured decreased after the first study year, despite consistent study methods. Although the precise reason for this decrease could not be identified, some possibilities included a severe freeze, dredging, increased visitation, and habitat changes that affected the area. It is also possible that the decrease in captures reflected natural, cyclical changes in green turtle population numbers.

Data amassed from this project have increased our knowledge of sea turtles in south Texas inshore waters. Additionally, we have used the research results to comment upon proposed projects, such as dredging of the channel, that could have impacts on sea turtles in the area. We plan to continue to incorporate these findings into sound management recommendations for the area. We hope that informed decision-making will afford these threatened and endangered animals the greatest protection possible.

Free at Last: Red Wolves in the Smokies

By Carroll Schell, Resource Management Specialist, and
Bob Miller, Management Assistant, Great Smoky Mountains National Park

When settlers first arrived in the Southeastern portion of the United States, they encountered large wolf-like animals. These animals ranged from the Atlantic Seaboard west to central Texas and northward to the Ohio River valley, an area which includes the Smokies. By the 1950's, however, they were extirpated from nearly all of their former range. Very few specimens were preserved, and very little was documented about the animal's appearance and life history.

It is believed that this animal, now known as the red wolf, was represented by three subspecies. Two of these subspecies became extinct during the first half of the twentieth century. In 1970, the remnants of the third subspecies were captured in southeastern Texas and southwestern Louisiana and placed in captive breeding facilities in an attempt to prevent extinction.

National Park Service policy states that the National Park Service will consider restoration of native species, where feasible, when extirpation was caused by the hand of man. Based upon our policy and the evidence that red wolves existed in the Smokies, park managers considered the program to be justified and initiated the restoration process.

In November 1991 biologists from the park and the U.S. Fish and Wildlife Service released a family of four red wolves as a temporary trial to find out if the Smokies still provided suitable habitat for this endangered mammal. The experiment was successful and lasted for about 10 months, after which the wolves were recaptured. The experiment provided project managers with enough information to move gradually into a permanent restoration of red wolves into the park. The experimental release used radio-tracking, observation, and wolf scat analysis to gather information in the following areas.

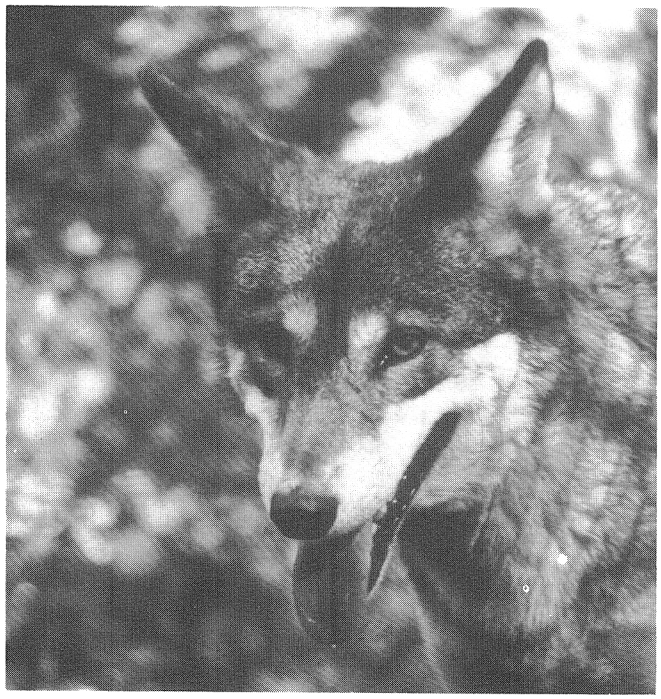
How much did the wolves wander? Early in the release the wolves stayed close to the release site, but by summer they settled into a 6-square-mile area near the Cades Cove campground and picnic area. Wolves occasionally entered the picnic area, perhaps looking for raccoons and rodents foraging for scraps, but, except for the adult male, all steered clear of humans and showed no interest in panhandling. After living 7 of his 9 years in a zoo, the adult male proved too tame to adapt back to the wild and was recaptured in January. Four times individual wolves left the park. In two cases the animals were recaptured and twice they returned on their own.

What did the wolves prey upon? Their diet was diverse and apparently adequate, as all wolves were healthy and had gained weight when recaptured. They ate mostly deer, raccoons, rabbits, and woodchucks.

How did the wolves interact with coyotes? Information on this point is sketchy because the batteries of most previously radio-collared coyotes had died by the time the wolves were released. All observed contacts of wolves and coyotes were hostile, but clear information on significant species displacement is not yet available. Biologists hope that as more red wolf families are released this relationship will become clearer.

How did the wolves react to humans? Besides its prey abundance, one reason for choosing Cades Cove for the release was the presence of visitors and livestock. Other than the male, wolves avoided humans and no human-wolf conflicts occurred. Visitors were, however, more apt to see them than had been expected, especially when the wolves were hunting woodchucks in the open during the day. One lesson drawn from the male's behavior was that young animals with little human exposure are the best release candidates as they are most apt to avoid humans.

How about livestock predation? There was some predation upon domestic animals; two turkeys were taken outside the park. A chicken and possibly a one-day-old calf were also taken in the Cove. The poultry was all taken at night and none of the birds were in pens. The calf was born away from the herd at the forest edge. Biologists found that newborn calves and their mothers that were moved into the herd and away from the forest were much more likely to be left alone by both coyotes and wolves. They also found that



in a few days calves were mobile enough to avoid being easy prey. The owner of the calf and the chicken was reimbursed from donated funds set aside to indemnify property owners. That fund contains over $15,000, with $10,000 more available if needed.

On October 9, 1992, a mated pair and their four six-month-old pups were released from a pen near Cades Cove. All six animals are radio-collared and are being tracked as intensively as the experimental animals. But unlike the earlier group, there are no plans to recapture this family, making these the first red wolves to reside permanently in the mountains since at least 1905. They also have the distinction of being the first wolves ever to be officially reintroduced into any U.S. national park.

Project personnel recently documented the first instance of red wolves killing an adult wild hog, a 60-pound sow. This is welcome news to park managers who have been working for decades to reduce the numbers of these destructive invaders.

A second family group was released on December 12, 1992, also into the northwestern section of the park but away from the open, pastoral Cades Cove area. That family, also made up of a mated pair and four six-month-old pups, was held in a park acclimation pen since June.

Plans developed jointly by the park and the U.S. Fish and Wildlife Service call for the gradual release of additional mated pairs/families each year until the park's carrying capacity is reached, possibly 50 to 75 animals.

Cooperative Effort Keeps the Delaware Clean

By Carol Hansen, Water Resources Planner, Delaware Water Gap National Recreation Area

The Delaware River is the eastern seaboard's only major free-flowing river. The exceptional water quality and outstanding recreational and fisheries resources found in its upper reaches were recognized in 1978 with the designation of two new segments of the National Wild and Scenic Rivers System. The Upper Delaware Scenic and Recreational River begins at the confluence of the east and west branches of the Delaware River at Hancock, New York, and runs downstream for 73 miles to a point just above Port Jervis, New York. Eight miles below, the Middle Delaware Scenic and Recreational River runs an additional 37 miles downstream through the Delaware Water Gap National Recreation Area (NRA) in Pennsylvania and New Jersey to the Delaware Water Gap.

Unlike most other wild and scenic rivers, both of these units lie within a two- to four-hour drive of major urban centers in the heavily-populated northeast. Escalating resort and residential development on adjacent lands, with an associated increase in wastewater discharges and nonpoint source pollution inputs, threatens water quality in the scenic rivers region. Delaware Water Gap NRA, the Upper Delaware Scenic and Recreational River, and the National Park Service Water Resources Division have worked in close cooperation with the Delaware River Basin Commission, an interstate federal planning and regulatory agency, to develop a water quality protection strategy for the two scenic river segments. This cooperative planning effort has resulted in revisions to the Commission's antidegradation policies and water quality standards that will protect existing water quality in the scenic rivers region from measurable change. The Commission adopted the new regulations on December 9, 1992.

The new regulations apply to the Delaware River from Hancock to the Delaware Water Gap, and to portions of intrastate tributaries lying within the boundaries of the National Recreation Area and the Upper Delaware corridor. Existing water quality in these reaches, as defined by rigorous statistical analyses, will be protected from measurable change through a tri-state watershed-based regulatory and management program. The regulations discourage, but do not ban, direct wastewater discharges to these waters and require that non-discharge and other natural treatment systems be used wherever feasible. Natural treatment options include spray irrigation, floating aquatic plant systems, and filtering wetland systems. In addition, the regulations require that all new or expanding wastewater treatment plants in the scenic rivers drainage area utilize "Best Demonstrable Technology," including advanced nutrient removal, ultraviolet disinfection or its equivalent, and specified operational safeguards to ensure continuous compliance with discharge requirements.

The policies and regulations were developed by National Park Service and Delaware River Basin Commission staff over a five-year period, with significant input from water quality professionals on the Commission's Water Quality Advisory Committee. Committee members represent the four Delaware River Basin states, the U.S. Environmental Protection Agency, and the public. Proposed new nonpoint source regulations are being finalized and should go to hearings in the spring of 1993.

The scenic rivers water quality protection strategy is precedent-setting for several reasons. Its primary thrust is to protect nationally significant waters from external threats without jeopardizing local growth and development in the surrounding region. The unique requirements for non-discharge and other natural systems, stringent point source requirements, and pending nonpoint source regulations are all directed toward maintaining the high level of water quality reflected in the statistically-derived criteria.

Fisheries Program Emphasizes Ecosystem Needs

By John Meyer, Fisheries Biologist, Olympic National Park

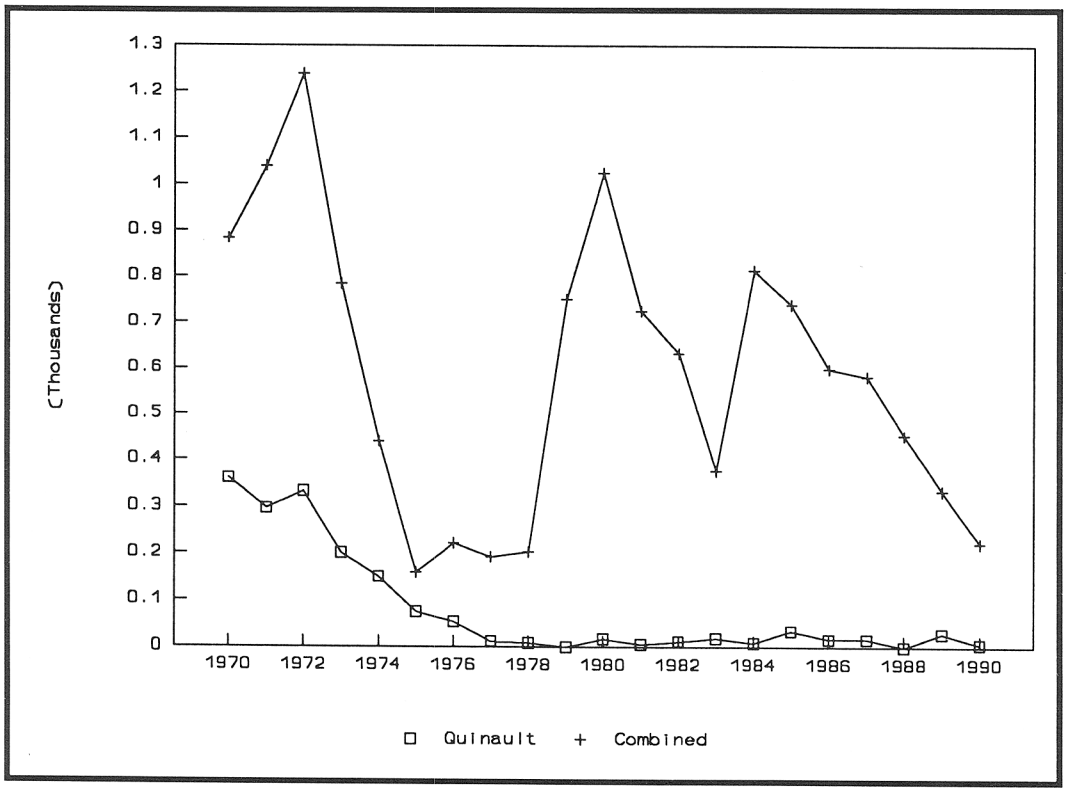
In the many pristine rivers and lakes scattered throughout Olympic National Park, salmon, trout, and char provide popular recreational fisheries opportunities. Visitors come to catch and view the fish during their annual spawning migration. In addition to their recreational value is the important role these fish play in natural ecological processes.

Unfortunately, demand for these fish is very high and takes its toll on the populations. Fish that migrate beyond the park boundaries are subjected to intense fishing pressure and various stresses due to habitat degradation. In an attempt to minimize the pressures on these fish, Olympic has recently begun an experimental management program emphasizing catch-and-release fishing.

Resource management agencies in the Pacific Northwest have begun only recently to recognize the ecological contribution made by fish. Of particular concern to Olympic is the role of fish in supplying prey to wildlife and recycling nutrients to aquatic systems. A study conducted on the Olympic Peninsula examined the fate of salmon carcasses after spawning and documented at least 22 species of birds and mammals that eat the fish carcasses. The fish are also important sources of prey in other life stages. Of 286 species of birds occurring in the park, 1/3 consume juvenile fish as a primary or incidental source of prey. Fish also appear to be important in recycling nutrients from the ocean into freshwater. Pacific Northwest streams are relatively low in basic nutrients due to frequent and sometimes intense floods. Fish carcasses and unhatched eggs are one method of replenishing nutrients flushed out of the system.

As the contribution of fish to natural processes becomes more evident, concern for their status has greatly increased. The American Fisheries Society reported that 214 stocks of salmon and steelhead are at risk of extinction or are of significant concern. Several of these stocks originate in Olympic National Park. Principal threats to these fish are habitat loss and degradation outside park boundaries, overfishing, and negative interactions with hatchery-planted fish.

Typical of the populations which have declined are those of summer steelhead (see figure). These sea-going rainbow trout return to many Olympic Peninsula rivers from June



Sport catches of summer steelhead in the Queets, Quinault, and Hoh rivers, 1970-90.

through October. They range in size from four to 20 pounds and are one of the most highly prized sport fish available. Unfortunately, catch records indicate that summer steelhead have experienced serious population declines. This trend is evident in the principal park rivers supporting this species. Catches on these rivers declined in the early 1970's, followed by an increase which coincided with large plants of exotic fish into nearby rivers. The Quinault River stock, which also declined in the 1970's, has never recovered despite restriction on fishing and remains at a very low level.

Coinciding with concerns regarding the status of these stocks, the National Park Service published guidelines for the management of natural resources, including fish. While allowing for fishing in parks, these guidelines stress the need to manage fisheries at levels which perpetuate wild stocks, ensure that ecosystem needs are met, and emphasize quality fishing. In an effort to meet these goals, Olympic implemented quality fishing regulations in 1992 on an experimental basis on three rivers. Fishing on these rivers is restricted to catch-and-release and artificial lures. These are the only rivers on the Olympic Peninsula currently being managed for catch-and-release except for the upper reaches of one other river outside the park.

Monitoring and evaluation of these changes will be challenging, as these rivers are relatively large, receive heavy amounts of rainfall, and have considerable glacial influence. Overnight they may rise from gentle streams to raging rivers carrying large old-growth logs and large quantities of sand and gravel. Since there are no baseline data against which to compare future changes, park staff have chosen to evaluate these regulations by comparing population responses against comparable control rivers. A variety of techniques such as electrofishing, spawner surveys, creel censuses, and snorkel surveys are being utilized to assess population response. Initial monitoring occurred in 1992 and will continue for at least three more years. If these changes are effective, park biologists are confident Olympic National Park will continue to offer quality fishing for trophy salmon, trout, and char in a pristine wilderness environment while providing viewing opportunities and meeting the needs of the ecosystem.

Raptor Monitoring Reaps Unexpected Rewards

By Steven H. DeBenedetti, Chief, Resource Management, and Julie Rechtin, Biological Technician, Pinnacles National Monument

The cliffs and rock faces at Pinnacles National Monument provide nesting habitat for several sensitive raptorial bird species, including prairie falcons and golden eagles. Peregrine falcons nested in the Monument until their numbers were decimated by pesticides in the 1950's and 1960's. The California condor was at least a seasonal resident at the turn of the century.

Pinnacles' rock formations also provide prime habitat for rock climbers and hikers. Rock climbing, especially new route development, has increased dramatically in the Monument throughout the past decade. The peak climbing and hiking season coincides with the reproductive cycle (territory selection, nest establishment, incubation, and fledging) of the cliff-nesting raptor species. A number of significant human/raptor interactions were reported in the middle 1980's; for instance, climbers were attacked or buzzed by prairie falcons, and a golden eagle stick nest was abandoned after an encounter with a park employee.

We have monitored raptor nest sites throughout the reproductive period (January-June/July) each year since 1987. The initial objective was to gather information needed to formulate management strategies sensitive to both the birds and park users that would ensure the long-term integrity of these species' reproductive environment. As a result of the monitoring, we have been able to define the length of the reproductive period, which varies somewhat with weather and if double-clutching occurs; document that nearly 90% of the nesting activity occurs upon the same formations each year; and record a relatively stable rate of nest establishment and fledging success throughout the six-year period.

Another objective of the monitoring program was to document human/raptor interactions incidentally. A formal study of this subject was beyond our means. However, a considerable data base has been amassed and is now being analyzed. Preliminary analysis indicates that prairie falcons modify their behavior in response to human presence. We can make no conclusions regarding the effect of this altered behavior on nesting success.

The knowledge gained by the initial monitoring program has led to a workable and respected management scheme. In a nutshell, rock formations where nests were established during the previous year are closed to climbing and off-trail hiking during the territory- and nest-establishment periods. If unoccupied by the end of the nest-establishment period, formations are generally reopened to use. Historic and potential nesting habitat are also surveyed during this period. Observed courtship, territorial defense, or nest establishment behavior results in closing corresponding areas. Once nests are established, the formation remains closed until fledging is completed. The Park Service notifies climbers

(Continued)

and hikers of changing situations via posted notices identifying sensitive areas on trailhead and visitor center bulletin boards, through press releases, and through mailers to climbing shops and organizations.

The benefits of the raptor monitoring program do not end here! The detailed and relatively continuous information gathered on the status of Pinnacles' prairie falcon nests made the Monument an optimum site for reintroducing the endangered peregrine falcon. Seven peregrine chicks were cross-fostered into prairie nests over a three-year period (1989-91). Specific knowledge of the history and physical characteristics of multiple nest sites and of the range in nestling ages present in the Monument enhanced the ability of recovery team personnel to capitalize on opportunities in other areas, and had no small part in our obtaining one peregrine chick without charge.

Unanticipated benefits of the monitoring program continue! No complete failures of a prairie falcon nest after incubation started were observed in 1987 or 1988. When a nest failed in 1989 we were curious to know why. Eggs from the failed nest were collected by volunteer rock climbers and analyzed at the University of California, Santa Cruz, Trace Organics Lab. Each egg contained very high levels of the fungicide hexachlorobenzene. A single nest also failed in 1990 for similar reasons. Conclusions are highly speculative. We don't know where the birds winter and we're not sure if it was the same pair that failed in both years. With certainty, we would not have known that pesticides continue to affect the Monument's raptor population without the monitoring program.

In 1992, a golden eagle was observed to fledge nearly three weeks after its expected date. Something had to be wrong. About two weeks later it was found dead. It was collected and sent to the U.S. Fish and Wildlife Service's Wildlife Health Center in Madison, Wisconsin, for analysis. It was emaciated and had damaged kidneys. Depressed brain cholinesterase levels strongly suggest that the eagle died from organophosphate exposure. The precise identity of the compound is currently under investigation. Again, without the monitoring program we would have no knowledge of pesticides affecting park wildlife.

As a direct result of the nesting raptor monitoring program, we have discovered and documented unanticipated threats to the long-term integrity of Pinnacles' nesting raptor populations. We can now formulate proposals to address the questions raised by these observations. Additional undocumented impacts to park ecosystems are undoubtedly occurring. An obvious conclusion that can be drawn is that a comprehensive resource monitoring program is needed at Pinnacles and in all parks.

International Cooperation Establishes Gaging Station on Important Alaskan River System

By Nancy Deschu, Hydrologist, Alaska Region, and Marv Jensen, Superintendent, Glacier Bay National Park and Preserve

The Tatshenshini and Alsek rivers constitute a large and diverse river system originating in Canada and cutting southwest through the Alaska coastal mountain range. Fed by massive glacial meltwater and sediment from the St. Elias and Fairweather mountain ranges, the two rivers converge just east of the Alaska-Canada border, forming the northern boundary of Glacier Bay National Park and Preserve. The lower reach of the Alsek River flows into Alsek Lake, which is fed by two major glaciers, and then empties into the Gulf of Alaska.

The Tatshenshini-Alsek river system is valuable to both humans and wildlife. The lake and lower river serve as a major migratory route and provide habitat for sea birds, ducks, geese, moose, bears, wolves, seals, and salmon. Because of its unique setting and its outstanding wilderness qualities, the river system has also become a much-sought-after destination for river runners and park visitors. Calving glaciers, wildlife sightings, dramatic weather, and rafting among icebergs are some of the memories adventurers carry away from the wild Tatshenshini-Alsek rivers.

The Alaska National Interest Lands Conservation Act (ANILCA) mandated that the National Park Service manage Glacier Bay National Park and Preserve "...to protect a segment of the Alsek River, fish and wildlife habitats and migration routes...." When faced with potential water resource-related threats from the proposed Windy Craggy open pit copper mine in the Tatshenshini watershed in Canada, the National Park Service in cooperation with the U.S. Geological Survey and the International Joint Commission (U.S. State Department) established a continuous hydrological recording gage station on the Alsek River, 10 km west of the international boundary and within Glacier Bay National Park and Preserve. The purpose in establishing the gage was to collect data on daily and seasonal river flow characteristics and baseline water quality. In August 1992, the Alsek gage was officially designated by the governments of the United States and Canada as an international gaging station.



On the Alsek River below its confluence with the Tatshenshini River, researchers make their way to the U.S.-Canadian gaging station. Data collected from the gage will be used to protect the Tatshenshini-Alsek River system, which provides valuable habitat for numerous wildlife species as well as outstanding recreational opportunities.

Both countries will cooperate in field data collection, analysis, and publication.

The establishment of the gaging station was a challenge for the National Park Service, the U.S. Geological Survey, and the Water Survey of Canada in terms of environmental constraints, international cooperation, and field logistics. Many factors had to be considered, including the remote location of the gaging station within a designated park wilderness, associated difficulties with access, and potential disturbance to river runners from gage station activities. Aircraft access to the gage station is carefully timed and routed to minimize disruption. Poor weather and severe winter conditions often complicate operations. There were, and continue to be, other operational challenges in conducting field work including identifying a stable channel section to take flow measurements; measuring massive glacial meltwater input and dramatic fluxes in flow; swift river velocity; employee safety; on-site equipment and boat storage; and the coordination of field activities between the United States and Canada.

The Alsek-Tatshenshini river system is driven by glacial meltwater contribution much more so than from the high rainfall received in the area. The first year of data from the gage site demonstrated that the winter flow (5,710 cubic feet per second) was 17 times less that the peak summer flow (97,800 cubic feet per second), relecting this tremendous glacial meltwater influence in the relatively warmer summer months of the year.

The gaging station will provide valuable baseline information for management decisions that are critical to the future protection of the Alsek and Tatshenshini rivers in the United States and Canada, especially in Glacier Bay National Park and Preserve. Some of these important river resources include diverse terrestrial and aquatic wildlife species that are dependent on a healthy riverine ecosystem; subsistence, sport, and commercial fisheries; and wilderness and recreational values. Of added importance is the fact that Glacier Bay National Park and Preserve was designated as a World Heritage Site in 1992; management of the lower section of the river is now subject to this designation, which requires protection of the universally significant characteristics upon which the designation was based.

As an international river with such unique and internationally recognized qualities, the Tatshenshini and Alsek rivers require a continued joint water monitoring program of this type by the United States and Canada. The National Park Service efforts in this endeavor are critical in carrying out this mission.

Monitoring Data Supports Hunting Closure

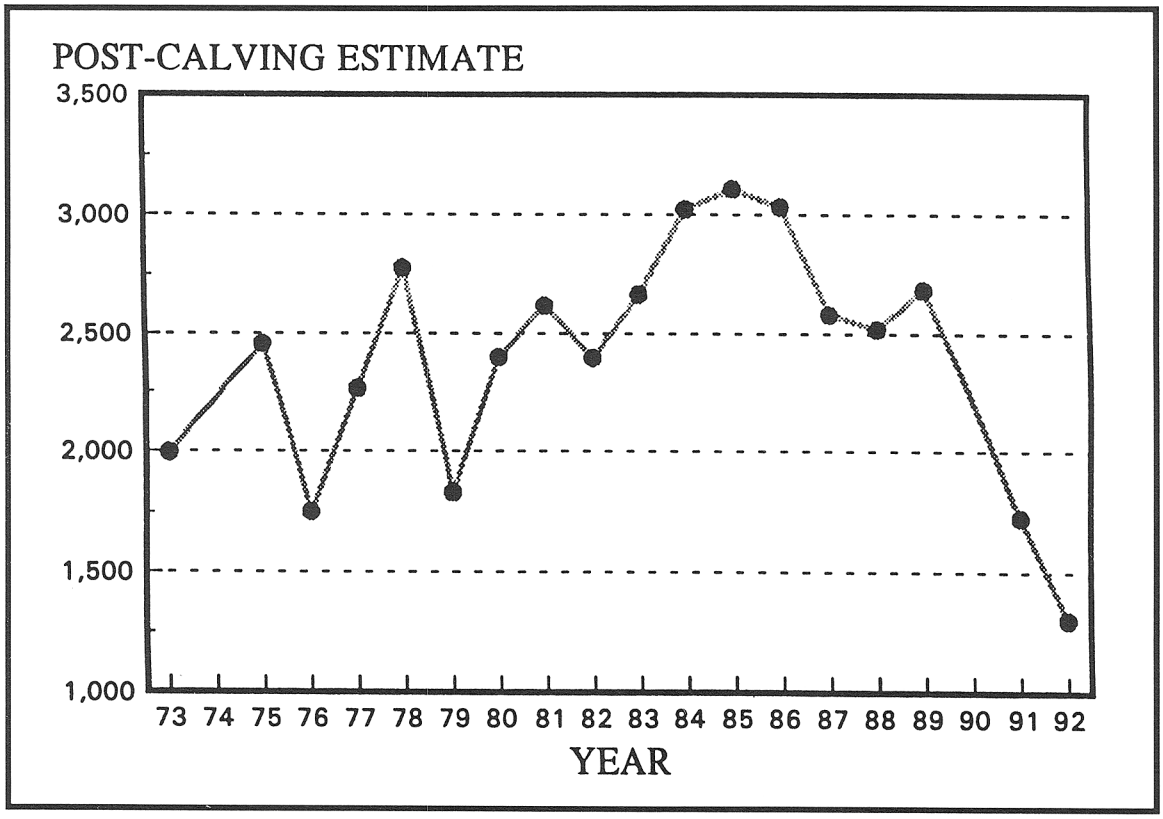
By Russell Galipeau, Chief, Resources Management, Kurt Jenkins, Research Wildlife Biologist, and Bill Route, Natural Resource Management Specialist, Wrangell-St. Elias National Park and Preserve

In 1992, Wrangell-St. Elias National Park and Preserve asked the Federal Subsistence Board to make a locally very unpopular decision to close subsistence hunting on the Mentasta caribou herd. The Board weighed the evidence at hand and decided in favor of closure for the 1992 hunting season.

The National Park Service is mandated by the Alaska National Interest Lands Conservation Act (ANILCA) to protect wildlife habitats and populations within Wrangell-St. Elias. Simultaneously, the Park Service is required by ANILCA to allow limited sport-harvest within the Preserve, as well as traditional subsistence uses of wildlife resources by local rural residents within both the Park and the Preserve. When wildlife populations decline, as in the current situation, ANILCA requires that subsistence harvest be given priority over sport use. Furthermore, the level of subsistence use must be consistent with the conservation of natural and healthy wildlife populations on Park Service lands.

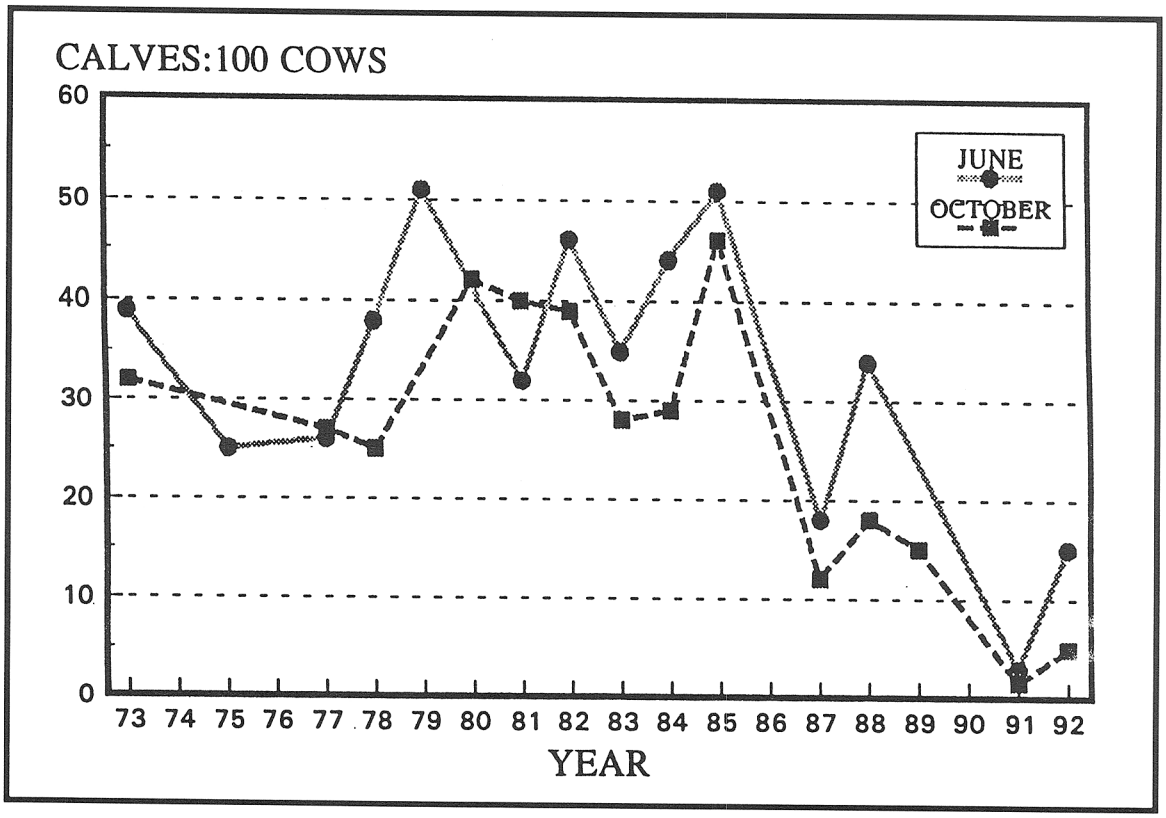
Historically, the Alaska Department of Fish and Game managed both sport- and subsistence-harvests of wildlife within the park. In 1990, the State of Alaska was found to be out of compliance with ANILCA by the Secretary of the Interior. Responsibilities for managing subsistence harvest of wildlife on these federal lands were assigned to the superintendent of Wrangell-St. Elias.

The Mentasta caribou herd, a small herd centered on the slopes of Mt. Sanford and Mt. Drum in the northern part of the park, is a subsistence resource for people of the upper Copper River Basin. Small population size, low recruitment, high predation rate, intermixing with adjacent caribou herds, suspected heavy poaching, and easy access for hunters all pose unique problems for management of sport and subsistence harvest of the Mentasta herd. Limited information is available on the abundance, distribution, and population dynamics of Mentasta caribou. This information is needed to develop appropriate caribou harvesting quotas that safeguard against overharvest. Population size, herd composition, and harvest statistics of the Mentasta herd have been monitored routinely by the state since 1972. Prior historical data on Mentasta caribou is scant, except for adult population estimates. (See accompanying graphs.)



Mentasta Population Trends

Post-calving population estimates of the Mentasta Caribou herd, 1973-92.



Calf Recruitment Trends

Calf recruitment trends (calves:100 cows) in the Mentasta caribou herd, June and October 1973-92.

Caribou harvest quotas established by the State for the Mentasta herd have become more restrictive as population size diminished and understanding of caribou/predator population dynamics has grown. Prior to 1977, harvest of Mentasta caribou was open to all licensed hunters. From 1977 to 1987, hunting of Mentasta caribou was limited to 150-428 issued permits, although actual harvests ranged from 52-112 caribou. In 1988, harvest was limited to bulls only. When the Park Service took over management of the subsistence harvest in 1990, it further restricted the harvest to 50 bulls, and to 30 bulls in 1991.

Determining the level of harvest, including whether any harvest will be allowed, requires information that can be defended in the public forum. The National Park Service must clearly articulate what harvest levels will meet subsistence needs while conserving "natural and healthy" populations. Producing a sustainable harvest of caribou, particularly in the presence of high predator populations and largely unpredictable winter weather, clearly requires close vigilance of caribou population trends and demographic traits.

The responsibility to manage subsistence hunting provided the Park Service with both the opportunity to take a more active role in managing wildlife populations and the challenge of implementing the spirit and intent of ANILCA. As a result of its new management responsibility, in 1990 the resource management staff accelerated a program of information gathering and analysis, active wildlife monitoring, and wildlife research.

Due to these efforts, the park was able to articulate to the local community and the Federal Subsistence Board why the subsistence taking of Mentasta caribou needed to be curtailed in 1992. First, monitoring data indicate that this rapidly declining herd has had no appreciable recruitment for two years. This suggests even a moderately low bull harvest could negatively affect the population. Secondly, the sustainable harvest of bulls is so low that it would require allocation of caribou to a very small number of subsistence users. Lastly, the Nelchina caribou herd (+45,000 animals) provides subsistence users of the area with an affordable and accessible alterative to harvesting the Mentasta herd.

The National Park Service's recommendation and the Federal Subsistence Board's action to close the subsistence season have not gone unchallenged. The Copper River Native Association filed suit in federal court claiming that the closure would cause irreparable harm to their people. The case is pending.

The park has embarked on an aggressive wildlife monitoring program to ensure that quality data are available to make important management decisions regarding subsistence uses of wildlife. Specific management goals and objectives for the Mentasta herd are under development that, together with quality data, will be used to base harvest quotas for subsistence hunting seasons in Wrangell-St. Elias. Additionally, the park will initiate an intensive research program on the Mentasta herd in search of answers to the important questions of what limits natural growth of the herd and how population status can best be monitored.

The Great American Fish Count

By Gary Davis, Research Marine Biologist, Channel Islands National Park

Why do people who would never condone killing and removing animals from terrestrial parks feel free to do so in marine parks? Don't we appreciate the values of natural marine ecosystems unimpaired by harvest? Are marine critters perceived as inexhaustible renewable resources?

Certainly no simple answers suffice for these complex questions. Lack of knowledge and poor awareness perpetuate the myth of an inexhaustible sea and deny human impact on marine populations. Scientific research will resolve many questions about fisheries, but changes in values and attitudes require public awareness and action. The Great American Fish Count seeks to bring out-of-sight, out-of-mind marine animals into the light to improve their plight.

The first fish count occurred in June 1992 when a small group of recreational divers conducted a standardized fish census to increase public awareness of the diversity and condition of marine fish populations. Modeling their efforts after the annual Audubon Christmas Bird Count, some 50 volunteers accompanied by park biologists identified 27 species and counted 4,804 fish near Anacapa Island in Channel Islands National Park, California. A modest beginning, perhaps, but then the Audubon count began with just 25 observers in 1900 and now brings together over 22,000 people to count birds in 1,563 locations. The Great American Fish Count organizers intend to conduct identical fish counts every year, and hope that their efforts will trigger similar counts in other areas. By carefully documenting their activities, the divers ensure that other observers can duplicate the census in following years. The information can be used to assess changes in species diversity, and perhaps to detect changes in numbers of fish. Eventually these counts will identify and raise public awareness of long-term trends in fish populations.

Currently, resource managers have only estimates of the weight or numbers of fish caught to guide conservation efforts. Actual changes in fish populations in response to harvest, pollution, and environmental factors are virtual mysteries. Yet these facts are vital for proper management of fisheries and essential to assess long-term effects of pollution and other human disturbances. Annual assessments of fish communities and populations provide a basis for evaluating health and sustained development of marine ecosystems. These standardized fish counts also provide amateur divers with an opportunity to actively participate in resource conservation.

In preparation for the 1992 count, the Channel Islands Council of Divers sponsored evening seminars on fish identification. Participants learned interesting tidbits about fish: Did you know that some of the rockfish in Channel Islands National Park are old enough to have voted for Abraham



Lincoln? They also learned that traditional ichthyology bases most fish identification on body features only observable on dead specimens or by close inspection, like striations on the liver or arrangements of gill rakers. Few texts, and even fewer academic courses, teach field identification of live, wild fish by augmenting morphology with habitat association, behavior, and natural coloration. The field is wide open for creative observers to become the Roger Tory Petersons of fish, and for schools and diving organizations to develop curricula focused on local fish.

Organizing an annual fish count is a great goal for diving clubs and training centers. Training, practice, and certification in underwater fish identification, logistical planning, and preparation of underwater data gathering equipment all provide opportunities to get together throughout the year. The annual fish count itself focuses broad community attention on both the diving organization's activities and on the condition of local marine resources.

Fish counts can also be competitive: Who found the most species verified by other observations or added more rare species to their life-lists? Spearfishing used to provide a competitive focus for divers, but as trophy fish and fish populations declined along the coast, interest waned. Annual fish counts could rekindle that interest in fish with a sustainable, non-consumptive use.

Initially dubbed the Great American Fish Count by organizers, the program received international attention from an article in Skin Diver magazine and may need a new name to incorporate the Bahamas and several Caribbean nations in 1993. As interest grows, other volunteer organizations will expand the annual counts into other areas to document the kinds and numbers of fish occupying coastal waters. Currently, volunteer groups plan to conduct fish counts in the Virgin Islands, Florida, and Wake Island in the western Pacific, in addition to expanded activity in California.

In addition to providing useful information, fish counts are fun! They add to our knowledge of fish behavior and ecology, and provide an educational social activity for divers focused on a non-consumptive resource use.

New Facilities Keep Bears Out of Human Food

By Dianne Ingram, Wildlife Biologist, Sequoia and Kings Canyon National Parks

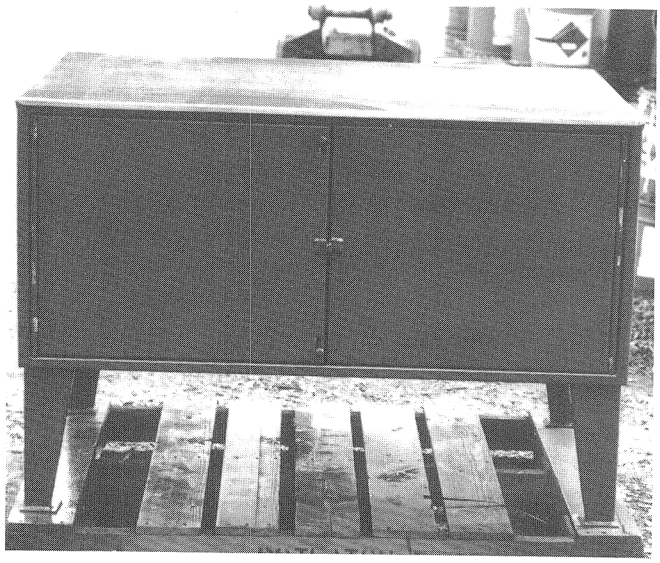
The bear management program of Sequoia and Kings Canyon national parks strives to restore and perpetuate the natural distribution, ecology, and behavior of black bears free of human influences. The program emphasizes preventive management in dealing with human/black bear interactions. Preventing problems requires making human food and garbage unavailable to bears. Bears that find human food often become destructive of property or potentially dangerous to people and eventually may need to be destroyed. Killing bears has a direct, human-caused impact on the wild bear population. Sequoia and Kings Canyon have recently introduced several new methods of dealing with food and garbage in the parks.

The bear-proof food-storage box was developed in Yosemite in the 1970's. A 1989-90 evaluation indicated that we needed approximately three times more food storage space to accommodate 95% of our campers. In 1992, park managers began phasing out the old-style box with boxes nearly three times larger. The metal shop at the Corcoran State Prison developed the new box in collaboration with the bear management staffs at Sequoia and Kings Canyon and Yosemite national parks.

The new boxes not only increase storage capacity, they also eliminate known safety and maintenance problems associated with the old-style boxes. The new box has stainless steel hinges, can be opened from inside, has double doors that open sideways, and comes with or without legs. They are purchased through California Prison Industries Authority, Folsom, California, for $425 each plus shipping. At this time, the Walsh-Healey Act prohibits purchases over $10,000 by federal agencies from state prisons. Our two parks need 1,500 of the new boxes--with this purchasing limit it will take 71 years to effectively bear-proof our campgrounds! The Western Region has committed to investigating legal alternatives.

Backcountry users currently have the following options to meet the parks' food-storage regulation: the food-storage

(Continued)



box, the bear-proof canister (also originated at Yosemite), and, as a last resort, either the counter-balance method or the 24-hour guard. Facing the reality that the counter-balance method often proves too difficult for even experienced back-country users, leaves unsightly tangled ropes dangling in the wilderness, and simply does not always work, park managers now strongly emphasize canister use over the counter-balance method. Currently, a local machine shop manufactures the only light-weight (<3 lbs), bear-proof food-storage canister currently on the market. Concessionaires at both parks began a moderately to highly successful sale/rental program of these canisters in 1992.

At Sequoia and Kings Canyon, as in most parks with bear populations, maintenance and bear-management staff work cooperatively to manage garbage problems. Currently we use several garbage disposal options: the mail-box-style lid on a 32-gallon garbage can, dumpsters modified to be bear-proof, and the Hid-a-Bag garbage can. With the mail-box style can, over-stuffed cans leave human food available to bears, back strain can occur from lifting the top to empty the garbage cans, and there is not a commercial source for mail-box lids. In 1992, Kings Canyon replaced all mail-box style garbage cans in some campgrounds with comparable bear-proof dumpster space. "Containerizing" a campground requires strategic placement of dumpsters in obvious locations at short intervals to make garbage disposal convenient for campers, a must because an inconvenient dumpster will not be used. This "dumpsters only" change in garbage management has been bear-proof, cost effective, and easier to maintain than the mail-box style can. While not perfect, these dumpsters provide an interim measure as the parks convert to Hid-a-Bag garbage cans.

The Hid-a-Bag provides a second alternative to the mail-box style garbage can for one of Sequoia's large campgrounds. It has a bear-proof latch, a 30-, 72-, or 130-gallon can option, easy garbage removal, and is commercially available. The disadvantages are cost and the need for special bags in the 72- and 130-gallon cans. (Regular bags tend to split if filled with heavy garbage.) The park's maintenance and bear-management staff are working toward eventually replacing every mail-box style can with these alternatives.

Large food-storage boxes, bear-proof food-storage canisters, and alternative garbage disposal facilities work in specific situations. The combination of methods tailored to each management need makes our bear-management program work.

J. W. "Bill" Wade, Shenandoah Superintendent of the Year for Natural Resources Stewardship



Because he has demonstrated an unusually high degree of commitment to the protection of natural resources, the Director's Award for Superintendent of the Year for Natural Resources Stewardship was presented in 1992 to J. W. "Bill" Wade, Superintendent of Shenandoah National Park. Wade has consistently made resource management a high priority at Shenandoah, even with limited funding. Wade recognizes that effective natural resource management requires a professional program supported by specially trained staff. On January 1, 1990, Shenandoah's new Division of Natural Resources and Science opened for business. In the past two years, the Division has added GIS, air quality, and inventory and monitoring staff positions to manage and implement the extensive GIS and air quality monitoring programs, as well as the innovative new inventory and monitoring program at the park. Threats to park resources, such as rapidly accelerating land use changes on private property surrounding the park, have received high priority.

Early in his tenure at Shenandoah, Wade began a "Related Lands Program" to identify risks both within and adjacent to Shenandoah National Park and to address these problems through cooperative long-term programs involving the public. When park staff became aware that Virginia Power had contracted for private companies to construct over 25 new power plants in the vicinity of Shenandoah National Park, Wade had in place data, staff, and a working relationship with the Park Service's Air Quality Division, all of which were needed to address this potential threat to park resources. Through these and many other actions, J. W. "Bill" Wade has become one of the most respected managers in the National Park Service.



Exotic Threats to Native Ecosystems

Managing Exotic Species in the National Parks

By Gary Johnston, Chief, Natural Resources Programs Branch, Wildlife and Vegetation Division

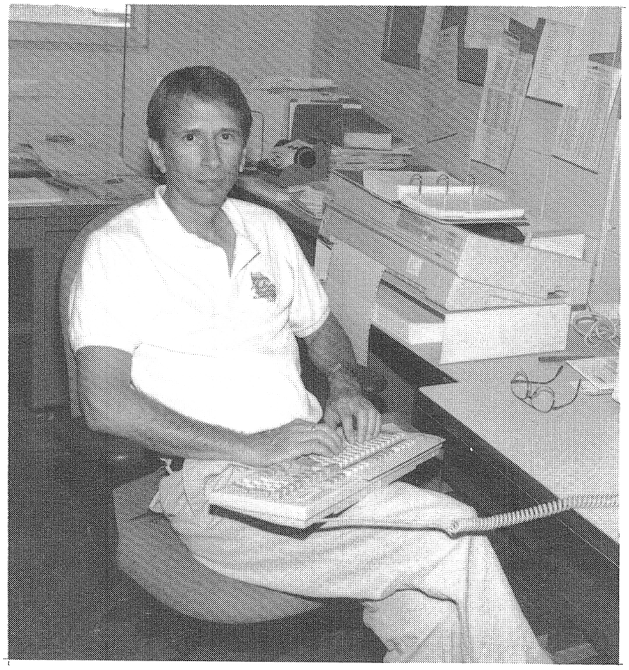
The National Park Service defines exotic species as any animal or plant species that occurs in a given location as a result of direct, indirect, deliberate, or accidental actions by humans. This definition is unique to the Park Service; it allows us to recognize and distinguish between changes to park resources caused by natural processes of animals and plants, such as natural range expansions, versus those changes caused by animals and plants introduced by humans. This distinction is important for managing the parks because the National Park Service is required by law to keep the parks as unaltered by human activities as possible. The distinction is also important because other organizations have different views about exotic species and have developed a long list of terms including alien, non-native, non-native but naturalized, and translocated. Each of these terms has a slightly different distinction regarding the origin of the species.

The National Park Service long ago recognized the significant biological impacts exotic plant and animal species can have on the natural and cultural resources of the National Park System. In 1933, Director Horace Albright stated "that the policy of the National Park Service is unalterably against the introduction of exotic species of plants or animals in the national parks or monuments, except for the occasional stocking of an otherwise barren body of water with some species of game fish...." National Park Service policy on exotic species has undergone several clarifications since this 1933 statement, and today is the strongest and most clearly worded of any of the land-managing agencies. Although the policy still allows for introduction of exotic species into the parks, the circumstances under which this may occur have been well defined and many restrictions have been placed on these introductions, including the introduction of fish species.

The impacts of exotic species on park resources are exhibited in a variety of ways. Many become obvious to those with experience in recognizing the changes caused; other impacts are subtle and only become apparent after extensive study. Exotic species disrupt or eliminate native

Robert F. Doren, Director's Award for Natural Resource Management

Robert F. Doren, Assistant Research Director at Everglades National Park and recipient of the 1992 Director's Award for Natural Resource Management, has made significant contributions to the field of exotic pest management and control. (See Doren's article on the effects of Hurricane Andrew on exotic species management in this report.) Faced with the massive invasion of Brazilian Pepper, which now poses one of the most serious long-term threats to the Everglades ecosystem, Doren developed the one method that has managed to control the plant and restore wetlands into the infested areas. Implementation of his restoration method, which involves removing disturbed substrate material that encourages growth of Brazilian pepper, required elaborate coordination with seven different federal, state, and county agencies; numerous concerned environmental interests; other scientists; and the news media. The project has been so successful in reestablishing wetland function that all regulatory agencies involved have now agreed to use this method on the remainder of the land in this area scheduled for wetlands restoration. This is an unprecedented acknowledgement by these agencies of the quality of this program. Through Doren's efforts on this project and his chairmanship of the Exotic Pest Plant Council (which represents over 200 government agencies, universities, corporations, environmental organizations, and individuals), over $100,000,000 of outside funding has been directed towards restoration work and exotic plant management and research in Everglades National Park.



plant communities by out-competing native species for growing space, water, or other important nutrients. Exotic species are known to hybridize with native species resulting in a loss of native genetic diversity and integrity. They also serve as disease reservoirs and transmit exotic diseases to native species, including desired historic plants or ornamental plantings. Exotic species can foul watering holes used by native wildlife or secrete chemicals into the soils which prevent native plants from growing, thus creating environmental conditions unsuitable to native species. Finally, as has been demonstrated by pigs, horses, and other exotic animals, they can transport exotic plant seeds, plant parts, and other exotic animals into new areas of parks, resulting in the establishment of new populations of these exotics. These impacts affect the park visitor through the loss of natural and cultural biological diversity, loss of aesthetics and loss of opportunities to view native species in a natural setting.

Actions to manage or remove exotic species from parks and surrounding lands cost the National Park Service and other land managers such as farmers, ranchers, foresters, and highway managers millions of dollars annually. According to our Resource Management Plan data base, the National Park Service will spend an estimated 9.9 million dollars over the next four years on the management of exotic animal and plant species. These funds will be expended on more than 450 separate projects in more than 109 parks. The projects include research to identify management alternatives, to inventory or monitor the status of various exotics, and to remove or manage populations of exotic species.

The need for resources to deal with our exotic species surpasses the funding available. For example, the Resource Management Plan data base indicates that our 1992 identified four-year unmet needs for exotic plants exceeds $45 million distributed over 109 parks and 241 different projects. For animals our unmet needs approach $8 million, distributed over 95 parks and 245 separate projects.

The National Park Service is working on a number of fronts to deal with exotic species problems. For example, we are working cooperatively with state and federal agencies in several parks and states to develop biological control agents to manage several exotic plant species. Through our Integrated Pest Management Program we provide technology transfer and pesticide management assistance to our parks, ensuring that the best management practices are used and that our native species are not damaged as a result of management actions. Many parks are working cooperatively with local organizations on specific weed management programs. In the Greater Yellowstone Area, for example, we are working with the states of Montana and Wyoming and the U.S. Forest Service on weed-management activities. The National Park Service was instrumental in establishing the Exotic Pest Plant Council; as a result of the Council's activities, Florida has passed legislation prohibiting the sale and distribution of *melaleuca* as an ornamental plant. This group is also working to establish chapters in other states. The National Park Service has been a leader in supporting and conducting research to develop and test contraceptive methods to manage populations of exotic horses and burros. We are also working to reduce or prevent new exotic species problems by educating local groups and park visitors about the dangers of releasing or introducing exotic species.

Hawaii Volcanoes Saves the Worst for Last

By Tim Tunison, Resource Management Specialist, Hawaii Volcanoes National Park

If you cannot manage the entire park now, start with your best areas! We have practiced this dictum at Hawaii Volcanoes National Park for the last seven years. Now we are not only successfully managing many of our best areas, but are also applying the knowledge gained to restore and protect our more degraded areas.

Reducing the impacts of introduced plants and animals is the major management challenge in Hawaiian preserves and parks. Considerable funding both by Hawaiian parks and regional and Servicewide programs has been directed towards this effort. The native Hawaiian biota have evolved without disturbance factors such as ungulates and fire, or the influence of ecologically important groups such as ants or rodents. These and other foreign animals have been introduced with far-reaching consequences for native insects, birds, and plants. Feral goats introduced by Europeans 200 years ago, along with fire spread by introduced grasses, have devastated much of the lowlands. Feral pigs disturb soil and vegetation and disperse exotic plants in wet and mesic forests. Over 35 of the 600 introduced plant species in the park are habitat-disruptive. Some of these form single-species stands; others alter fire, nutrient, and soil-moisture regimes in ways harmful to native ecosystems.

Managers were successful in controlling feral goats throughout almost all of the park by the early 1980's. However, a parkwide approach to pig and particularly exotic plant control was clearly not working. There were too many species spread over too great an area, and funding and knowledge were woefully inadequate.

In 1985 we changed our approach to exotic species management. We identified sites for intensive management based on the criteria of intactness, rarity, manageability, species richness, and potential for interpretation and research. We also attempted to pick representative sites in all six ecologi-



A resources management technician monitors recovery of vegetation in a tree fern-dominated rainforest, following the removal of pigs and exotic plants.

cal zones of the park and called these sites Special Ecological Areas (SEAs). In SEAs we controlled all disruptive exotic plants, even those not manageable on a parkwide basis or targeted for biological control research. We generally controlled pigs in broader areas surrounding and including the SEAs, but in some areas pig and plant control units coincided.

We started modestly with six SEAs totalling 3,800 hectares. SEAs varied from 12-1,500 hectares. The first two years required lots of hard work, setting up monitoring transects and plots, building fences, hunting pigs, and removing exotic plants with picks, saws, or herbicide. Many hundreds of worker-days were provided the first summer by a British volunteer group, Operation Raleigh, and by the Youth Conservation Corps. Workloads dropped sharply after the initial control efforts. By 1990 we were able to expand the six SEAs and establish six additional ones. We are now managing the most disruptive exotic species in 12,000 hectares or 15% of the park's area, much of which is bare lava flows. Feral pigs have been removed from approximately 30% of their habitat in the park. Eleven species of exotic plants were targeted for management. These are now controlled to manageable levels in all twelve SEAs, with population densities reduced ten-fold and the workload five-fold.

Weed populations, vegetation recovery following removal of ungulates and exotic plants, rare plants, birds, and insects are monitored in SEAs by park resources management and research personnel. SEAs now provide a baseline for understanding and monitoring Hawaiian ecosystems with minimal influence of exotic species. They also serve as models for management of more weedy or degraded areas. Management focus is now shifting to these areas, particularly in mesic and rain forest areas.

A great deal has been learned about how to control exotic species by managing them in SEAs. Before 1985 we threw up our hands at the weed and pig problems. If we could not control a serious exotic plant throughout the park, we had to hope that biological control agents might someday be found. Now we have not only protected our most diverse and intact sites, but also have developed the confidence and knowledge to manage more challenging areas. This incremental, experimental approach to management, starting with the biologically-most-important areas, makes seemingly overwhelming management problems approachable.

When Do Exotic Plants Become Weeds?

By Jim Sweaney, North District Resource Management Coordinator, Yellowstone National Park, and Thomas C. Wylie, Natural Resources Specialist, Rocky Mountain Region

The ecological impacts of exotic species cause familiar management problems in many National Park System units. Less well known is another facet of exotic species management: the politics of weeds. Exotic plant species become a political issue when they are legally designated as noxious weeds or undesirable plants by state and local governments. Not all states distinguish between exotic and native species in the legal definition; however, the number of native species designated as noxious weeds is extremely low and absent in most of the states in the Rocky Mountain Region. One example of a state's legal definition for a noxious weed or undesirable plant is this one from Colorado: "an alien plant or parts thereof, which meets one or more of the following criteria; (a) it aggressively invades or is detrimen-

tal to economic crops or native plant communities; (b) it is poisonous to livestock; (c) it is a carrier of detrimental insects, diseases, or parasites; (d) the direct or indirect effect of the presence of this plant is detrimental to the environmentally sound management of natural or agricultural ecosystems."

Parks that have been invaded by leafy spurge, knapweed, Canada thistle, and other undesirable plants are looked upon as weed reservoirs by neighboring farmers, ranchers, and weed control boards. Generally, park funds are not sufficient to adequately control these species within the parks. Adversarial relationships tend to develop across jurisdictional boundaries, and the National Park Service is seen as uncooperative. This viewpoint was expressed in a letter to a park superintendent which said, "... it is time you begin doing your part in keeping the Canada thistle population under control in the park." Significantly, even though plants do not recognize jurisdictional boundaries, control efforts for exotic species have not commonly reflected the joint planning, analysis, and monitoring needed to be successful.

One park's need for multi-agency cooperation was recognized in a 1990 memorandum of understanding involving Yellowstone National Park. The purpose of that memorandum of understanding "is to encourage and formalize the cooperative relationship necessary for effective management, coordination and implementation of Noxious Weed programs among Forest Service; States of Wyoming, Montana, Idaho; National Park Service and Bureau of Land Management within the Greater Yellowstone Area." A work group with representatives from each of the member agencies developed *Guidelines for Coordinated Management of Noxious Weeds in the Greater Yellowstone Area*, which has become a model for other cooperative endeavors in the area. The guidelines provide for a public awareness and a noxious weed prevention program in addition to inventory, mapping, monitoring, control, and reporting procedures. Most importantly, the guideline provides for the establishment of weed management areas in which jurisdictional boundaries are replaced by natural boundaries that facilitate an integrated weed management program. A cooperative agreement has been negotiated for the first weed management area involving Yellowstone. The weed management area includes a part of the southwest corner of the park in which leafy spurge was first detected in 1991. The weed management area also includes lands in Fremont County, Idaho; Teton County, Wyoming; and the Targhee National Forest.

In November 1990, two months after the Greater Yellowstone Area memorandum of understanding was signed, Congress amended the Federal Noxious Weed Act of 1974 by adding Section 15: "Management of Undesirable Plants on Federal Lands." Among other things, the amendment requires federal agencies to "complete and implement cooperative agreements with State agencies regarding the management of undesirable plant species on Federal lands under the agency's jurisdiction." The amendment also validates the National Park Service integrated pest management approach; it requires the use of "integrated management systems" for controlling targeted plants.

The state of South Dakota moved fairly quickly to propose implementation of Section 15. In August 1991, the South Dakota Weed and Pest Control Commission hosted a meeting to initiate a cooperative weed management program. A broad spectrum of county, state, and federal work group participants developed an action plan supporting integrated pest management strategies and calling for a statewide, multi-agency memorandum. An inter-agency working group was established with nine members from the South Dakota agriculture and transportation departments, the USDA Animal and Plant Health Inspection Service, the U.S. Forest Service, the Corps of Engineers, the Bureau of Indian Affairs, the Bureau of Land Management, the U.S. Fish and Wildlife Service, and the National Park Service. The working group used the Greater Yellowstone Area weed management guidelines and memorandum of understanding as models for preparing the state guidelines and memorandum of understanding. The 1992 South Dakota memorandum of understanding is still the only signed agreement resulting from the Federal Noxious Weed Act amendment of 1990, but numerous other requests and inquiries are on the table.

Exotic plant species become a political issue when they are legally designated as noxious weeds or undesirable plants by state and local governments. Parks that have been invaded by leafy spurge, knapweed, Canada thistle, and other undesirable plants are looked upon as weed reservoirs by neighboring farmers, ranchers, and weed control boards.

The challenge now is to negotiate other state agreements, review existing older agreements for compatibility with the 1990 amendment, and implement the weed management area program at the park level. In no case will agreements abrogate National Park Service authority, policy, or guidelines. Working out on-the-ground noxious weed control agreements may be difficult, but in the long run, cooperation based on weed management areas should be more effective than most current efforts. It is understood that lack of funding will still be an issue. However, Section 15 also establishes the duty to "adequately fund an undesirable plants management program through the agency's budgetary process," and the Rocky Mountain Region is working to address this requirement. In any case, the benefits already experienced indicate the need to move ahead. The Greater Yellowstone Area and South Dakota initiatives provide a foundation on which to build and improve cooperative noxious weed management elsewhere in the Rocky Mountain Region.

Dampening Loosestrife's Enthusiasm

By Steve Cinnamon, Chief, Resource Management Branch, Division of Natural Resources, Midwest Region

Introduced to the United States from Europe early in the 19th century by horticulturalists, bee keepers, and gardeners, purple loosestrife has subsequently become a menace to aquatic ecosystems. Purple loosestrife occurs in inland, marsh, and river systems in every state above the 35th parallel except Montana and Alaska. Purple loosestrife is an aggressive plant which out-competes all other vegetation in wetlands and, if left unchecked, will eventually dominate any wetland area.

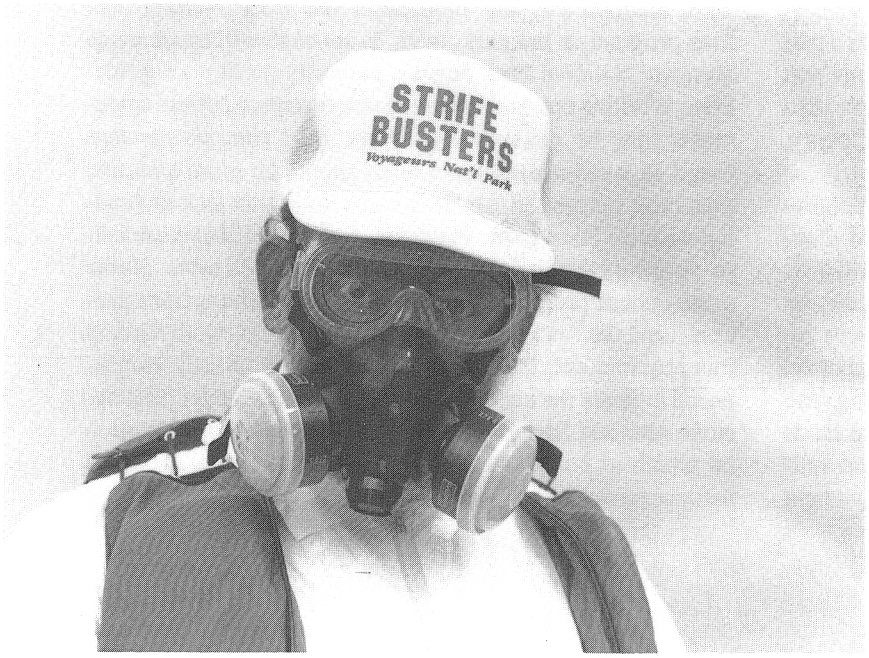
The primary reason parks make the effort to control purple loosestrife is to maintain undisturbed ecosystems as habitat for native species. Purple loosestrife readily colonizes disturbed environments by tolerating various chemical and physical conditions. Once in an area, the plant outcompetes native plant species, leading to loss of valuable habitat for native wildlife species. Drainages and watersheds not surveyed and subsequently treated will become infested, resulting in damage to populations of songbirds, amphibians, turtles, ducks, fish, and other aquatic life. The plant's prolific seed production and subsequent seed vitality make control efforts difficult. The seeds disperse by drifting on water and by being transported by various means, such as on birds' feet, vehicles, or the cooling systems of outboard motors. Purple loosestrife can also spread vegetatively through adventitious root and shoots.

Several states have rated the species as a noxious weed and have proactive programs designed to eradicate or check loosestrife populations. State and park areas are elevating the consciousness of citizens by providing information on the impacts of purple loosestrife and encouraging citizens to report plant distribution. Other areas use volunteer groups to assist on eradication projects. States which do not have aggressive programs face the eventual loss of habitat by subsequent invasion and proliferation by the plant. Lack of an effective state program complicates a park's program to search for and eradicate plant populations.

The first management step needed by parks and land management agencies is to document the extent of plant distribution. Visual inspections take time and must be repeated annually to verify that distributions are stagnant. The monitoring window varies yearly with climatic conditions. A new monitoring technique is being developed by the University of Wisconsin-Madison as part of a project funded by the Natural Resource Preservation Program. Researchers use aerial photography to determine the infrared wavelength signature, which can be used on a regional basis to locate plant populations.

Efforts to control loosestrife generally include foliar sprays or cut-stem treatments with herbicides approved for aquatic sites. Hand-pulling small specimens works with isolated stands of immature plants. Private landowners, including The Nature Conservancy, have applied similar techniques on lands adjoining Apostle Islands. Areas of small infestation are handled manually, but require return trips to eliminate plants sprouting from the residual seed bank and root stock. Hand-pulling is only effective with very small plants where the entire root can be pulled. If the entire root is not removed, additional plants will sprout from the root stock and pulling can actually increase numbers of plants.

Park Service areas have been working with park neighbors in controlling the pest. Apostle Islands personnel work with The Nature Conservancy on land adjacent to the park, and the Great Lakes Fish and Wildlife Commission has been conducting control efforts on nearby slough areas. Voyageurs National Park staff work closely with a coalition of government and conservation organizations to control the plant on a lake-wide or watershed basis.



Park areas may have a slight management advantage over adjoining state land managers due to the smaller size of management units and the lesser extent of infestation. Although park crew sizes are small, aggressive eradication efforts have been underway using approved pesticides in Acadia, Voyageurs, Apostle Islands, and Indiana Dunes, to name a few.

Plants initially introduced for ornamental purposes have escaped cultivation and pose a serious threat to our aquatic ecosystems. The long-term effects of the presence of loosestrife are yet to be determined. The complete elimination of loosestrife from North American aquatic environments seems unrealistic.



Resource managers fight to protect this scenic landscape at Whitman Mission National Historic Site from cheatgrass and yellow starthistle invasions.

Whitman Mission Studies Exotic Plants to Search for Possible Control Methods

By Roger Trick, Chief of Interpretation and Resource Management,
Whitman Mission National Historic Site

Cheatgrass invaded the West in the 1890's, displacing native grasses in many areas. A century later, yellow starthistle is now moving in and taking over many of these same areas, as well as colonizing new territory. Future efforts to restore native grasslands will be made even more difficult with this plant than where cheatgrass prevails.

What makes yellow starthistle so tough? Why does it dominate some areas and not others? What can resource managers do to stop the invasion? Park managers and cooperating university researchers are just beginning to answer these questions. Whitman Mission National Historic Site, in partnership with Eastern Oregon State College, participated in a research project during 1992 designed to provide basic ecological information on these aggressive exotic plants.

Both cheatgrass and yellow starthistle grow very rapidly at first. However, yellow starthistle roots grow much deeper than cheatgrass roots. During dry periods in early-summer, cheatgrass turns brown and stops growing. By this time, each plant may have produced 10 or more seeds. Yellow starthistle, with its longer roots, can continue to use moisture deeper in the soil. By late summer, star thistle has released most of its seeds, as many as 120 per plant on the average.

By knowing the soil depth and moisture, resource managers may be able to predict which plant will create the most problems at any given site. Yellow starthistle will probably never be a threat on areas at Whitman Mission with shallow soil. These areas may have lots of cheatgrass, however. Most of Whitman Mission has the deep, rich soil which makes this part of Washington an excellent wheat-producing area. Unfortunately, the deep soil also provides perfect habitat for a yellow starthistle invasion if park managers fail to adequately manage the plant.

At Whitman Mission we have restored almost 60 acres of the park back to the native grasses that were growing here 150 years ago. Each year we try to do another 5 or 10 acres. Once a thick stand of grass is growing, yellow starthistle and cheatgrass virtually disappear from that area. Some of these native grasses grow 6-8' tall. In the fall the stems die, but by early the next spring new grass is growing from last season's roots. Whitman Mission park managers have found that burning the accumulated dead grass stems every 3 or 4 years seems to re-invigorate the plants. The thicker the plants, the less opportunity for cheatgrass and yellow starthistle to invade an area. With these techniques, we hope to be able to prevent these exotic plants from taking over Whitman Mission National Historic Site.

Preparing for Zebra Mussels in the St. Croix

By Sue Jennings, Resource Management Specialist, Saint Croix National Scenic Riverway

The potential introduction of zebra mussels into the St. Croix National Scenic Riverway poses a serious threat to the biological and recreational resources of the St. Croix River. Zebra mussels, native to the Caspian Sea, were accidentally introduced into the Great Lakes in 1986 when transoceanic ships discharged ballast water into Lake St. Clair. Highly prolific, the zebra mussel is capable of removing significant amounts of phytoplankton from the water column. Degradation of aquatic communities which are dependent on phytoplankton for food is likely to occur in areas zebra mussels have colonized. Already, zebra mussels have caused nearly complete extirpation of native mussels in the Lake Erie basin.

The zebra mussels' proclivity for hard surfaces makes docks, breakwalls, boat hulls, and engine outdrives susceptible to rapid colonization. Engine repairs due to clogged cooling inlets lead to costly repair bills. Beaches and shorelines in infested areas end up with extensive deposits of sharp-edged shells that create safety hazards and exorbitant associated clean-up costs. Because the mussel has spread so rapidly, researchers have not had time to develop adequate management methods.

The Great Lakes are now heavily infested with zebra mussels and additional infestations have been found in New York and the Ohio, Illinois, and Mississippi rivers. The mussels require a firm substrate for attachment; commercial and recreational boats are the primary means of dispersal. Because it is a tributary to the Mississippi, the St. Croix River is at risk for zebra mussel infestations.

The 405 km (250 mi) St. Croix National Scenic Riverway represents one of the most diverse National Park System units in the midwest. The St. Croix watershed has been described as a sanctuary containing the best preserved presettlement remnant of the Upper Mississippi aquatic community. The watershed contains a diverse and complex fish community consisting of 94 fish species, including several federally endangered candidate species. Indicative of the exceptional water quality and overall health of the St. Croix are the 41 species of fresh water mussels, including the federally endangered Higgins' eye pearly mussel and the only known population of the winged mapleleaf mussel. The significance of the St. Croix River in supporting a diverse assemblage of mussels species is recognized by a growing number of aquatic biologists.



Zebra mussels colonizing hard surfaces such as this clam shell cause problems for boat owners, dock owners, and barefoot beachwalkers. Clean-up costs can be exorbitant.

With this in mind, the National Park Service and the U.S. Fish and Wildlife Service organized a multi-agency project to survey the Lower St. Croix River in the fall of 1992. Personnel from the National Park Service, the U.S. Fish and Wildlife Service, and other state and federal agencies assisted in this endeavor. The purpose of the monitoring effort was to estimate the number and distribution of zebra mussels in the lower St. Croix River, to enhance public awareness of the problem, and to provide baseline data for the development of an interim response plan. Over twenty-six miles of riverway were surveyed. Crews using boats inspected shorelines, boat hulls, docks, and other suitable substrates. The crews also visited with boat owners and marina operators to inform them about zebra mussel impacts. A team of SCUBA divers was employed to survey deep water substrates, piers, buoys, and native mussel beds.

No adult zebra mussels or signs of zebra mussel infestation were found on any of the inspected sites. This does not necessarily mean that there are not zebra mussels in the St. Croix; rather, the results indicate that the number of zebra mussels is very low and that reproduction is not likely to occur this year.

The next phase of the management strategy is the development of an interim response plan and its implementation in the spring of 1993. Our goal is to reduce the rate of zebra mussel spread and solicit public support while the long-term response plan is developed for 1994. The interim plan will recommend public education and other actions, including restricted access, to deter zebra mussel invasion during the 1993 navigation season. Park staff will distribute public service announcements, send outmass mailings to registered boat owners and businesses, hold public meetings, and use interpreters and other information disseminating techniques to get the message out. Using permanent plots established in the 1992 survey, comprehensive monitoring for zebra mussel adults and larvae will continue. The long-term management plan will be developed by an interagency task force which will explore in-depth the management options for the protection of the natural, recreational, and commercial resources of the St. Croix National Scenic Riverway.

Although it is unrealistic to completely prevent zebra mussels from entering the St. Croix River, we do hope to slow the rate of spread and gain time until viable zebra mussel management methods are available. Information gained by this effort should be valuable to other parks and areas with water resources that are confronted with zebra mussel infestations.

Restoring Klamath River Basin Bull Trout to Crater Lake National Park

By Mark Buktenica, Aquatic Biologist, Crater Lake National Park

Bull trout were once found in most major river systems in the Pacific Northwest and Canada. In the past 30 years, their distribution has been significantly reduced, and many populations have become extinct. Habitat degradation and introduction of exotic fish species are believed to be the primary causes for the recent decline.

The Klamath River Basin in Oregon is the southern limit of bull trout populations today. These Klamath River populations are genetically distinct from other Pacific Northwest bull trout populations and qualify as a separate species for consideration under the Endangered Species Act. (Bull trout are currently listed as candidate species for listing under the Endangered Species Act by the U.S. Fish and Wildlife Service.) The American Fisheries Society has petitioned the Fish and Wildlife Service to list the Klamath River Basin bull trout as an endangered species.

A 1947 stream survey in Sun Creek, Klamath Basin, Crater Lake National Park, indicated that bull trout were well distributed in the headwater stream along with brook trout, which had been stocked into the stream in the early 1900's. A survey of the fish populations and instream habitat in Sun Creek in the summer of 1989 revealed that the bull trout population was reduced to 130 adult fish and was restricted to a 1.9 km (1.2 mi) section of the stream. Brook trout were distributed throughout the stream. Hybridization and competition with the introduced brook trout appeared to threaten this native bull trout population with a high risk of extinction.

This alarming information led the park to draft a bull trout restoration plan in 1990. The objectives of the plan were to restore the remnant population of bull trout to historic numbers and distribution in Sun Creek, remove the introduced brook trout, and prevent the future invasion of exotic species from waters outside of the park. The plan called for additional research in 1990 and 1991 to verify the distribution and abundance of the bull trout; evaluate stream chemistry, temperature, flow, retention, and travel time; and conduct surveys of amphibians and aquatic insects, with an emphasis on looking for rare, threatened, and endangered taxa. Laboratory tests were conducted to determine the specific toxicity of the fish toxin Antimycin on trout in Sun



The bull trout recovery team used an antibiotic that is toxic to fish to remove brook trout from one section of Sun Creek. Here, team members neutralize the antibiotic below the downstream barrier.

Creek. Alternative locations for a "back-up" population of bull trout were evaluated, including hatcheries and isolated creeks within Crater Lake National Park. Alternative methods for fish removal also were evaluated.

In October 1991 a recovery team was assembled to evaluate the recovery plan, the research to date, and to offer recommendations on implementation of the plan. The recovery team included personnel from the National Park Service, the U.S. Fish and Wildlife Service, the U.S. Forest Service, the Desert Fishes Council, the Oregon Department of Fish and Wildlife, and Oregon State University; the group had expertise in fish population restoration, fish toxins, electrofishing, fish barriers, genetics, and fish and macroinvertebrate ecology.

The long-term goal of the plan was to eradicate brook trout from Sun Creek within the boundary of Crater Lake National Park. An immediate objective was to remove as many brook trout as possible from this area to allow bull trout to increase in number and disperse downstream. The loss of any bull trout during the removal process was not an acceptable risk as the viability of such a small population was already in question.

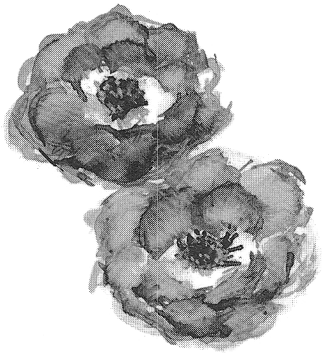
During the summer of 1992, a restoration program was initiated. Two log and rock fish migration barriers were constructed near the park boundary to prevent the invasion of exotic fishes. Brook trout were removed from Sun Creek with non-lethal electroshockers upstream of the bull trout population. Data were collected on fish weight, length, sex, abundance, biomass, and distribution.

Recent literature suggested that electroshocking may have higher injury and mortality rates on fish than previously believed. Therefore, electroshocking for brook trout in the bull trout section of the stream was tried with caution in 1992 and abandoned when the bull trout showed signs of stress. Alternative methods for removal of the brook trout in the bull trout section are currently being evaluated. A special study was conducted in the fall of 1992 to evaluate rates of injury to brook trout from three different types of electroshockers.

Non-lethal samples of fin tissue were removed from brook trout, bull trout, and brook trout-bull trout hybrids in 1992. These samples will be used for genetic analyses to evaluate hybridization and to compare the genetic make-up of Sun Creek bull trout with other Klamath and Columbia Basin bull trout populations.

The recovery team agreed that electroshocking techniques would not be effective in fish removal downstream of the bull trout owing to increased stream flow and structural complexity of the stream channel. Therefore, brook trout were removed with Antimycin. Antimycin is an antibiotic that is toxic to fish at dosages as low as 4 parts per billion. Antimycin is not toxic to mammals and birds, but is toxic to amphibians and to many species of aquatic insects. The Antimycin was successfully neutralized below the lower barrier and upstream of the park boundary with potassium permanganate. Brook trout were collected at block net stations and by "dip-netters" along the stream. No amphibians were collected and preliminary observations suggested that insect mortality was low.

A sampling program will be initiated in 1993, supported by Natural Resources Preservation Program funding. The objectives of the program are to monitor the recovery of insect and bull trout populations and to continue the removal of exotic brook trout.



Research Aids Resource Management

Inventory Assessment Directs I&M Program

By Thomas J. Stohlgren, Ecologist, Natural Resource Ecology Laboratory, Colorado State University

Released in 1992, the National Park Service's Guidelines for Inventory and Monitoring of Natural Resources (NPS-75) presents the National Park Service with an awesome task: "To assemble baseline inventory data describing the natural resources under its stewardship, and to monitor those resources forever."

Why does the NPS need these accurate inventories of natural resources? Some reasons are obvious. The National Park System provides both fully-protected habitats for the long-term maintenance of biological diversity and a baseline against which to measure change. Increasingly, decisions affecting park resources are made in spite of or are delayed because of insufficient biological information. Accurate assessments are needed both of the occurrence of species or genotypes in parks and of the status and condition of populations. These assessments are essential to form natural resource management policies that effectively manage the natural diversity within existing parks, and to identify potential new or expanded reserves that preserve biotic diversity that are not now effectively protected within the National Park System.

To know what we needed to find out, we had to find out what we already knew. As a first step towards this goal, we assessed the status of existing information. (The group working on this project included scientists and researchers throughout the Park Service, as well as a colleague from the University of California.) We provided a categorical summary of the status of species lists for various taxonomic groupings (e.g., vascular plants, birds, etc.); assessed mapped information on vegetation, soils, and geology; and cataloged aerial and satellite imagery and other geographic information. For most of the park units, biological technicians spent a few days to a week in each park interviewing key research or resource management personnel and examining resource records, research libraries, map collections, and other records of biological resources. Some of the park surveys were completed by regional office personnel or park staff. Species occurrence records were grouped by taxonomic category (for most parks, vascular plants, mammals, birds, reptiles, amphibians, and fishes). Park personnel were asked to estimate the geographical completeness, ecological completeness, and taxonomic completeness of the existing records.

Some of the major findings are as follows:

1. Although most parks have species lists for at least some biological groups, about 80% of the lists are reported to be less than 80% complete in their taxonomic, geographic, and ecological (community type) coverage. Fewer than 30 of the 252 parks surveyed had inventories thought to be greater than 95% complete for any one of the biological groups. For all biological groups except vascular plants, the status of inventories most often reported by park staff was "poor to non-existent." Most parks had more complete information on vascular plants and birds than on other groups, but many parks had large gaps in information (i.e., high composite scores) of even these better-known groups. Very few parks had attempted park-wide systematic surveys for any of the biological groups. Some of the systematic vegetation surveys were geographically broad, but certainly missed some rare habitats and taxa. Some intensive monitoring programs are relatively complete taxonomically, but are restricted geographically.
2. While 43%, 28%, and 24% of the 252 parks surveyed had maps of vegetation, soils, and geology, respectively, none of these maps appear to have been systematically checked for accuracy after their creation. Most of the maps are old and of unknown validity. Vegetation classification schemes are not standardized among parks.
3. Staff in small parks (< 100 km^2) generally reported less knowledge about biotic resources than staff in larger parks. This is important for two reasons. First, most natural area parks in the National Park System are small: 56% of the park units are less than 100 km^2, 77% are less than 500 km^2. Second, some of our other research findings show much of the National Park System's biological diversity may be in the small park units. Small parks often lack: physical resources to maintain voucher collections; computer facilities and expertise to manage large datasets (e.g., geographic information systems); or readily available assistance from Park Service or university scientists.
4. Inventory efforts vary among taxa. Disproportionate attention is given to some "popular" groups (plants, mammals, birds) or to taxa within groups (butterflies, trees, large mammals, etc.). Inconspicuous or "unpopular" groups (most invertebrates and non-vascular plants) have been largely ignored.

The National Park Service is beginning to respond to these identified needs by initiating a Systemwide Inventory and Monitoring Program. One goal of this program is to provide each of the approximately 250 natural area parks with essential resource information including an annotated computerized bibliography of past research, more complete information on the occurrence and distribution of vascular plants and vertebrate species, standardized sampling protocols for acquiring and managing new flora and fauna information, and maps of vegetation types, soils, and geology.



Finicky Wolves Prefer Caribou

By Bruce Dale, Wildlife Biologist, Alaska Regional Office

At least 160 moose and probably 200 sheep were present within the boundaries of the Sixty-mile Wolf Pack. Survey results indicated that only 90 or so caribou wandered in small groups through the pack's territory. Yet, when we saw the lunging tracks of a dozen large ungulates and the torpedo-shaped tracks of wolves in pursuit, we were pretty sure of what species we'd find at the bloody spot at the end of the trail. Another caribou kill! We peered out the windows of the little Piper Cub aircraft and saw seven gray members of the Sixty-mile Pack busily devouring the remains of an adult caribou.

As wildlife researchers from the Alaska Regional Office, we had witnessed that scene many times while studying wolf ecology and the effects of subsistence wolf harvest in Gates of the Arctic National Park. Among other objectives, park managers needed information to determine the relationship between the resident wolf population and the massive Western Arctic caribou herd. Currently numbering more than half a million, the herd ranges primarily outside Gates of the Arctic and National Park Service management responsibility. If wolves in Gates of the Arctic rely heavily on caribou for food, changes in the status of the herd could affect the moderately-harvested wolf population.

By following the wolves daily and back-tracking their movements to previous locations, we determined that caribou constituted 93% of kills that four wolf packs made in March 1989 and 1990 and November 1990. Each pack killed caribou at rates that provided 1/10 of a caribou per day for each wolf, even when moose and sheep were more abundant. When wolves were able to make a caribou kill, they frequently made multiple kills and averaged 1.2 caribou for each successful attack. Including moose and sheep kills, each pack of wolves averaged an ungulate kill every two days. Clearly, wolves can be highly selective and efficient predators, but the factors which influence their selection of prey species remain important mysteries for researchers to explore.

The multi-faceted study, started in 1986 and nearing completion, has proven exceptionally valuable to the National Park Service as Alaska continues to develop its controversial Strategic Wolf Management Plan for Alaska, which includes provisions for aerial wolf reductions. Knowledge of wolf behavior, population dynamics, and harvest will help Park Service managers conserve these charismatic and controversial symbols of the wilderness for future generations.

Equine Contraceptive Techniques Studied on Assateague Horses Show Positive Results

By John Karish, Regional Chief Scientist, Mid-Atlantic Region

A free-roaming herd of horses provides a major attraction for visitors to Assateague Island National Seashore. However, as an exotic species, these horses can have serious effects on the natural ecosystem of the park. Based on extensive research studying the effects of the horses on the island's vegetation, the National Park Service set a population limit of 150. In 1984, the Assateague population was at 110 and increasing 10% yearly. To respond to this rapid population growth, a feral horse management plan prepared by the park recommended investigation into the use of antifertility drugs as a means of long-term population stabilization. This research has made a major contribution to developing population controls for wild horses and has also provided a strong foundation for long-term management approaches.

Contraceptive Effectiveness Studies In 1986, researchers began to test the feasibility of inhibiting fertility of the Assateague horse population. Initial objectives included testing the effectiveness of remotely-delivered hormones to inhibit ovulation in mares and to lower sperm counts in stallions. As reported below, these approaches proved ineffective, but suggested important factors for the next stage of testing.

The mare hormone study using microencapsulated norte-histerone resulted in six of six mares treated in March 1986 delivering foals in 1987. These same six mares had a 50% foaling rate in 1986. This suggested that the hormones actually enhanced fertility. While this study failed completely to achieve the primary goal of infertility, the discovery that mares could be treated by a remote delivery system with considerable ease was of great value to future work.

To study the effectiveness of the male hormone, microencapsulated testosterone propionate, four stallions of proven fertility and in possession of harem bands were treated between February and March 1986. In 1987, mares of proven fertility associated with the treated stallions had a fertility rate of 29%. However, mare exchange between bands became common where it previously had not been noted. Thus, it was not known whether all foals born to mares in the treated stallion groups were in fact sired by those stallions. Despite a clear reduction in fertility, the decrease in the mares' band fidelity would require that the hormone be administered to a high number of stallions.

Early Results These early research results indicated several requirements for successful treatment methods:

1. Treatment should focus upon mares. Mares are considerably easier to approach and treat, and inter-band movements will not interfere with effectiveness.
2. The treatment should be deliverable in small volumes, making injection easier.
3. The treatment should be deliverable in a single administration to minimize the need for subsequent applications.
4. The treatment's action should be reversible.

Immunocontraceptive Studies on Mares An alternative to hormone-induced fertility control is immunocontraception. A study showing that solubilized porcine zonae pellucidae (PZP) vaccine injections inhibited fertility in captive mares suggested an effective alternative. In 1988, the contraceptive efficacy and safety of the PZP vaccine in free-roaming feral mares were tested under field conditions on Assateague.

In 1988, approximately 100 feral mares inhabited Assateague Island National Seashore. Ages, fertility records, and identifying markings are known for almost all animals. Between February and March 1988, 29 mares were darted with an initial inoculation of vaccine. Later in March and April, 26 of these mares were inoculated a second time and 18 a third time. Six control mares were darted but received no vaccine.

Fifteen of the 29 treated mares were pregnant at the time of inoculation and all of these produced foals in 1988. Half of the six control mares produced foals in 1988. In 1989, however, only one foal was present among the 29 treated mares (born of a mare that had received only one vaccination), while there were again three foals among the six control mares. This compares to a fertility rate of 55.5% for the 29 treated mares for each of the two previous pretreatment years.

This study provided the first description of successful fertility inhibition among uncaptured, free-roaming wildlife by means of remotely-delivered immunocontraception. The success of the PZP vaccine in suppressing fertility among the Assateague feral mares is based on its ability to inhibit fertilization or possibly implantation. Pregnancy did not alter antifertility effects of the vaccine nor was the normal progress of pregnancies or health of the foals affected by vaccine administration. These results suggested that PZP immunocontraception is an attractive alternative for the management of feral horse populations.

"Booster" studies After evaluating the results of the immunocontraception studies, experiments were conducted to assess how long the vaccine remained effective, and the effectiveness of a single annual booster. During February and March 1989, 14 of the 26 mares that received multiple doses of the vaccine in the original study received a booster inoculation of PZP. Only one booster-inoculated mare produced a foal in 1990, compared to a fertility rate of 33% for mares previously treated but not "boostered." Ten of the 14 booster-inoculated mares were given PZP booster vaccinations in March of 1990 and 1991. The same mare that delivered a foal in 1990 delivered a foal in 1991, the only one of the 10 to foal. None of the 10 mares inoculated during 1991 delivered foals in 1992. The untreated control mares exhibited a 50% fertility rate in 1991 and a 75% rate in 1992; five control mares died during a January 1992 storm. During four years of treatment since 1988, only two foals were produced. The same treated mare gave birth to these foals, possibly because she is a "low-responder" to the vaccine.

A female foal born to a mare that had been exposed to anti-PZP antibodies while pregnant gave birth in 1992. This is an important event because it demonstrates that *in utero* exposure to antibodies did not adversely affect the foal's fertility as an adult.

These studies have demonstrated that PZP immunocontraception of feral horses:

1. can be carried out remotely,
2. will not adversely affect pregnancies in progress or the health of the foals exposed *in utero*,
3. will not change herd social behaviors,
4. can be sustained by annual booster inoculations, and
5. is reversible over a two-year period.

The small volume required and the aqueous base facilitate administration by dart. Remote delivery eliminates the possibility of injury associated with capture activities. The reversibility of the vaccine's contraceptive effects is an advantage both biologically and politically, since it is unlikely that public opinion will favor irreversible sterilization. Behavioral integrity, which is particularly important in social animals such as horses, was maintained in treated animals; bands with treated horses remained intact and exchange of mares between bands was within normal limits. No hormones are involved which might impinge upon the brain and change behavior directly. Finally, the protein nature of the contraceptive antigen precludes the possibility of passage of the antifertility agent through the food chain; protein, unlike hormones, cannot be passed along intact from the treated animals that die to the predators' tissues.

Future efforts This work, initially funded by the National Park Service, has been largely responsible for obtaining three additional years of support by the National Institute of Health to continue the study of PZP effects on fertility and examine effects on ovarian function. In addition, researchers are studying a PZP vaccine that would give initial fertility control plus a time-release booster in one remotely-delivered dose.

Assateague will review the feral horse management plan based on the results of these studies and other recent research on grazing impacts and population modeling. Any proposed use of immunocontraception for management purposes will be carefully designed to insure a continuous and varied flow of genes through the herd and protect against possible long-term effects of the vaccine upon ovarian dysfunction.



Jay Kirkpatrick, the principal investigator for the Assateague immunocontraceptive study, identifies horses prior to administering a remotely-delivered immunocontraceptive. Positive research results to date indicate the treatment may provide a tool Assateague resource managers need to control the rapidly expanding horse populations on the island.

Snowfall Tips the Balance of Wolf-Caribou Relationships in Denali National Park

By Layne Adams, Wildlife Research Biologist, Alaska Region

Figuring out the effects of weather on natural systems, particularly those involving long-lived large mammals, requires long-term studies, a solid dose of good luck, or both. The wolf and caribou research in Denali National Park has had both. With six years on the books, the research project approaches comparatively long-term status and has been lucky in the constant quest for funding. Good luck definitely was the rule with snowfall patterns during the study. Major changes in winter snowfall had profound effects on these naturally-regulated wolf and caribou populations, and scientists from the Alaska Regional Office, the park, and the U.S. Fish and Wildlife Service have been busy trying to keep track of them.



During the first two years of the study, snowfall was below average, as it had been for nearly a decade. The caribou herd numbered around 2,500 animals and was growing at about 10% per year, with about 45 wolves inhabiting their range. Wolves primarily killed moose; the few caribou they took were either very young or very old. The chance that a given caribou cow would die during the year was only 2-3%, and those deaths were caused by bears or wolves.

With the first snowy winter everything changed. Caribou were forced to stay in areas where snow was not too deep, such as windblown alpine ridges with little food available, or to dig through the deep snow to forage. Further, their ability to run away from wolves was hampered by the deep snow. Wolves switched from killing moose to killing caribou, which were very vulnerable, and were able to kill caribou of all ages. The mortality rate for caribou cows increased eightfold to 19%, with wolf predation accounting for most of these deaths. With this increase in the availability of prey that were relatively easy to kill, the wolf population grew to about 74, a 64% increase in one year!

The next three years had above average snowfalls with new records set in the winter of 1990-91. The wolf population peaked at about 80, then began to slowly decline. Wolves continued to kill caribou at high rates. Bulls were primarily affected; between 1990 and 1991 nearly half of the bulls (about 500 animals) died. The caribou population as a whole leveled off by 1990 and then crashed, declining by 25% in the following two years.

In addition to the losses of adult caribou described above, the reduced availability of food on the alpine ridges and the increased energy costs of getting to food buried under deep snow showed up with decreased calf production. Coincident with the increased snowfall, the age at which cows first produced calves was delayed from two-years-old to three-years-old. Fewer adult cows were pregnant, calves were born 28% lighter in weight, and stillbirths were noted for the first time in the study. Survival of calves also declined

Long-term research on wolf and caribou interactions in Denali National Park indicates that major changes in the relationship result from consecutive snowy winters.

dramatically, from nearly 56% surviving to four months in the early years to about 9% in the later years. When calves were born large, the few that died were killed by predators primarily within the first 10 days of their life. The smaller calves born in later years died in greater numbers during this early 10-day period but continued to be killed throughout the year, indicating that they were more vulnerable to predation.

Knowledge of the natural interactions of wolves and caribou has great implications for management of these species. Wolves and caribou are not hunted in Denali, but they are in most Alaskan parks and preserves. Insights from Denali provide a framework for managing hunting in National Park Service areas as well as throughout the remainder of Alaska and Canada. Understanding the roles of natural factors like weather in population fluctuations of these species is essential to recognize effects of hunting as well as other human-induced changes.

What's next? If we have some easy winters, we hope to learn how the tough winters these last few years will affect recovery of the caribou herd and their interactions with the wolf population. If deep snows continue, we will learn how wolves adjust to lower numbers of caribou in the park. We have also begun studying the role of grizzly bears in this predator/prey system and hope to begin studying how changes in wolf, bear, and caribou interactions affect moose populations, the other major prey species.

Fire Aids In Butterfly Habitat Management

By Eddie L. Childers, GIS Specialist, Indiana Dunes National Lakeshore

The Karner blue (Kb) butterfly population at Indiana Dunes National Lakeshore appears to be the third largest population of this diminutive endangered species in the entire world. A survey and mark-release recapture study completed this summer suggested that Indiana Dunes has the largest natural setting in the world capable of supporting a large population of the Kb butterfly.

Managing habitat over such a large area is a challenge. The report from the survey, which was conducted by a Nature Conservancy biologist and implemented by Lakeshore and Conservacy staff, contains information regarding the life history, habitat requirements, population dynamics, and suggested management strategies for the continued survival of the national lakeshore's Kb butterfly population. One of the methods that Indiana Dunes will evalute is the use of prescribed fire to maintain butterfly habitat.

An intriguing behavioral characteristic of the Kb butterfly involves larval feeding behavior. The larva feed exclusively on wild lupine, a plant that grows in sand prairie, oak savanna, and other open or semi-open habitats. Wild lupine is a shade-intolerant plant. Consequently, some type of management regime must be employed to maintain the open areas to keep other plant species from shading out and eliminating the lupine from the habitat. Fire management is the most useful strategy for maintaining wild lupine and, subsequently, Kb butterfly habitat at Indiana Dunes National Lakeshore.

The complicating factor is that, though fire can help to stop the loss of Kb butterfly habitat from overshading, fire also burns the Kb butterfly eggs that are laid on the lupine plant stems. This means that to initiate a management ignited prescribed fire the national lakeshore must get permission from the U.S. Fish and Wildlife Service to incidently "take" the eggs of an endangered species. The Fish and Wildlife Service is prepared to grant permission, knowing that fire will have the long-term benefit of increasing numbers of the Kb butterfly, as long as no more than 1/3 the habitat is burned at a time. The national lakeshore will strive to maintain 10-30% of unburned areas within burn units to assist the natural recolonization of the butterflies.

The fire management strategy recommends a series of management ignited prescribed fires. Four burns, each of approximately a quarter of the butterfly habitat, will be accomplished during the next four years. No two adjacent areas will be burned in successive years, allowing the Kb butterfly populations from unburned areas to recolonize the burned area. The fire interval for each of the four sites will be five to eight years. This burn interval will hopefully increase the number of lupines and allow Kb butterfly populations to increase beyond pre-burn numbers.

Resource managers will also try mechanical control such as cutting and trimming of woody sprouts that overshadow lupines to compare effectiveness and labor costs with fire methods. The obvious benefit of mechanical control is that there would be very little incidental take of Kb butterfly eggs. Fire may work best in large areas and mechanical control in small areas.

Population studies will be conducted annually to determine the effects of fire management on Kb butterfly populations. All of the Kb butterfly population areas will be digitized into the geographic information system (GIS). The GIS enables analysis with aspect, topography, elevation, vegetation, and other habitat parameters to better determine population trends, population dynamics, and critical habitat for the endangered Kb butterfly.

Helping these small, beautiful butterflies survive in the face of extinction will require the cooperation and best efforts of professionals proficient in GIS, fire management, animal ecology, and resource management.



Mount Rainier, a Decade Volcano

By Barbara Samora, Natural Resource Specialist, Mount Rainier National Park

Mount Rainier is the most hazardous volcano in the Cascades, with a greater potential for sector collapse, debris flow, and major eruptions than other area volcanoes. The mountain is the highest volcano in the Cascade Range, and towers over a population of more than 2.5 million in the Seattle-Tacoma metropolitan area. Its drainage system via the Columbia River potentially affects another 500,000 residents of southwestern Washington and northwestern Oregon. Mount Rainier poses significant dangers and economic threats to the region, but despite such hazards and risk has received little study.

Eruptions of Mount St. Helens and other volcanoes throughout the world increased public awareness of the hazards posed by Mount Rainier. In 1989, the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) established a task group for the International Decade for Natural Disaster Reduction. The task group selected several volcanoes for focused study during the next decade, calling them "Decade Volcano Demonstration Projects." The IAVCEI chose seven volcanoes in developing countries as "Decade Volcanoes" and two in the United States--Mount Rainier and Mauna Loa.

In September 1992, the National Park Service participated in a planning workshop sponsored by the National Academy of Sciences, the University of Washington, and the U.S. Geological Survey. Workshop participants worked on developing a plan through the National Academy of Sciences to organize research needed to evaluate the hazards and risks associated with Mount Rainier, and to develop communication efforts of the risks for appropriate planning activities. Participants included earth scientists, experts in societal response to natural hazards and risks, and representatives of several local, state, and federal agencies. Improved interaction and communication among all those who contribute to the decision-making process, including scientists, engineers,

economists, sociologists, planners, and politicians, will be a key aspect of the Decade Volcano efforts.

Research goals and strategies for mitigating risks and reducing disasters have been identified and will be submitted to the National Academy of Sciences in early 1993. Geologists stress that Mount Rainier must be considered an active volcano capable of eruptions of unknown magnitude. Its record of inactivity in the 20th century and minor activity in the past few hundred years should not mislead us; there is no reason to suspect that the volcano will not erupt again. Even small eruptions of certain types could cause significant risk due to the heavy snow cover on the volcano and the population living along the volcano's slopes.

As part of the study, regional work around the volcano will focus on defining the location and recency of fault zones and on understanding the crustal framework that has led to the development of Mount Rainier. The inherent instability of the Mount Rainier edifice implies the potential for sector collapse from seismically-induced ground shaking. Increased understanding of the seismic zone that lies several kilometers west of the volcano is vital for hazards assessments.

Scientific studies will include geologic mapping, petrogenetic studies, eruptive history and behavior, geothermal-glacial interactions, hazards assessment, surveillance of changing conditions (seismic activity, uplift or ground distention, volcanic gas emissions, glaciers), and ecological research to assess the impacts and biological responses following a disturbance. Social science concerns to be addressed include volcanic risk assessment, including parameters of the physical event; effects upon society at key scales and societal adjustments to hazards at key scales; patterns of social response; and communication of risks. Mitigation strategies will be developed, including development of public education materials and establishing a hazards information network for sharing information about existing knowledge, current and planned research and projects, and progress of projects in both text and geographic information system formats. To promote practical application of research findings, this network would link researchers, county planners, emergency services planners, and others assessing and coping with Mount Rainier hazards.

The National Park Service will play a key role in the Decade Volcano project. Coordination of efforts among the numerous investigators involved in these studies will be essential at all levels to maximize efficiency in the difficult logistical setting of Mount Rainier; to minimize sample collecting, paleomagnetic drilling, and trenching of exposures within the park and designated wilderness; and to ensure adequate scientific exchange among investigators to minimize information gaps and optimize scientific synthesis.

Irrigation-induced Landslides Threaten Fossils

By Jon Riedel, Park Geologist, North Cascades National Park

Three million years ago during the late Pliocene epoch, Lake Idaho covered most of the southwestern part of the state. Diverse habitats at the lake's edge thrived in a climate wetter than today's. Rapid sedimentation where rivers entered the lake preserved specimens of many creatures now extinct in North America, including the Hagerman Horse, the mastodon, the lake cat, and the camel. Fifteen thousand years ago, a huge flood roared through the Snake River Plain exposing the bones of these creatures. The best exposure of these fossils occurs along the steep bluffs that rise 600' above the Snake River near Hagerman, Idaho.

Hagerman Fossil Beds National Monument was established in 1988 to protect this area, one of the world's important sites of Tertiary fossils. Human use of the landscape adjacent to the fossil beds now threatens their integrity. Large landslides caused by irrigation of the plateau above the Monument's bluffs present the most serious of these threats. Between 1983 and 1991 there have been five large landslides within Hagerman Fossil Beds. Although the landslide threat to the fossils has been recognized for a decade, research in 1992 focused on removal of lingering doubts about the cause-effect relationship between the landslides and irrigation of the plateau.

In the late 1970's, ground water seeps and water-dependent vegetation appeared on the arid bluffs between 3100' and 3400' elevations. Several lines of evidence indicate that the irrigation project is the source of the water feeding these perched aquifer systems. The regional aquifer system is too deep to be the source of water for the seeps. The appearance of all of the new landscape features coincided with initiation of the irrigation project, and all of the seeps, new vegetation, and landslides are located on the bluff face in close proximity to two irrigation canals. In addition, the water level in several monitoring wells and the seep surface flow respond to seasonal use of the canals. Finally, irrigation elsewhere in the arid interior northwest has caused landslides in similar deposits.

All five landslides occurred where perched aquifers intersect the bluff face and discharge as seeps. Water from seeps saturates the loosely cemented fossil beds, causing decreased shear strength, increased pore water pressure, and excess weight within the sediments. Rotational movement down

slope of large blocks of the sediments occurs when a water saturation threshold is reached. As the blocks move down slope, the landslides turn into debris flows and debris slides.

Once a landslide has occurred, areas adjacent to and above the failure begin slumping. Cracks associated with all five of the landslides indicate they are still active. If the cause of the landslides was stopped today, mass movements would continue for years until the perched aquifers dried and the sheer cliffs slumped to a less vertical slope.

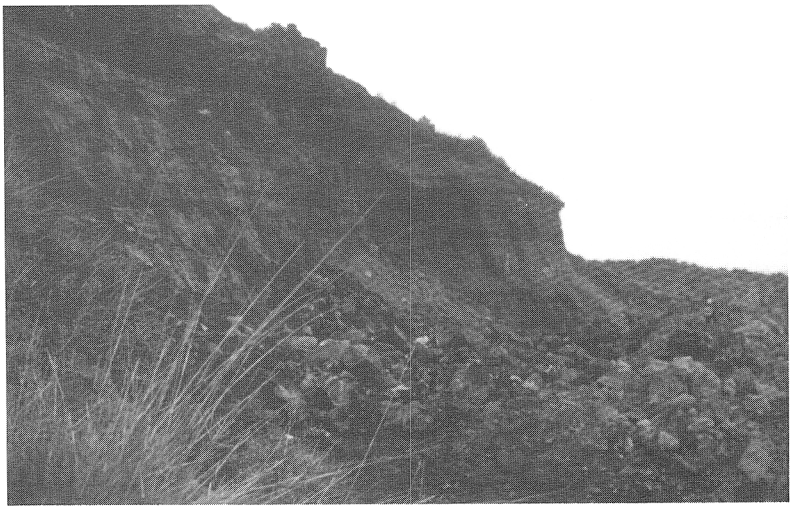
Well logs, gamma ray logs, and previous stratigraphic studies were used to develop a detailed picture of the hydrostratigraphy of the area. Based on this information, it was possible to identify the presence of several perched aquifers and to determine ground water flow directions.

There are at least four perched aquifer systems, and their dynamics are complicated. Each has the characteristic of a layer that restricts the downward flow of water. The best understood aquifer occurs when water seeping downward reaches an impenetrable ribbon-like basalt flow that resulted when the once-marshy sediments were baked from the heat of the lava. The water flows horizontally from northeast to southeast.

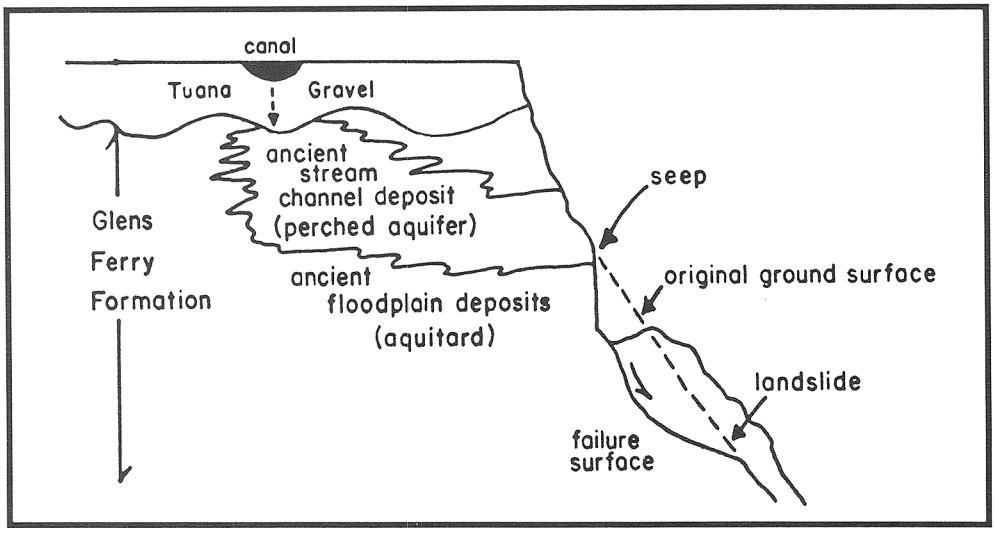
Two other perched aquifers move vertically from the irrigation canal. The flow likely follows connections between desiccation cracks within the floodplain deposits, ancient river channels, and other features yet unidentified. Cross-bedding of sands within the ancient river channels suggests that they flowed from north to south.

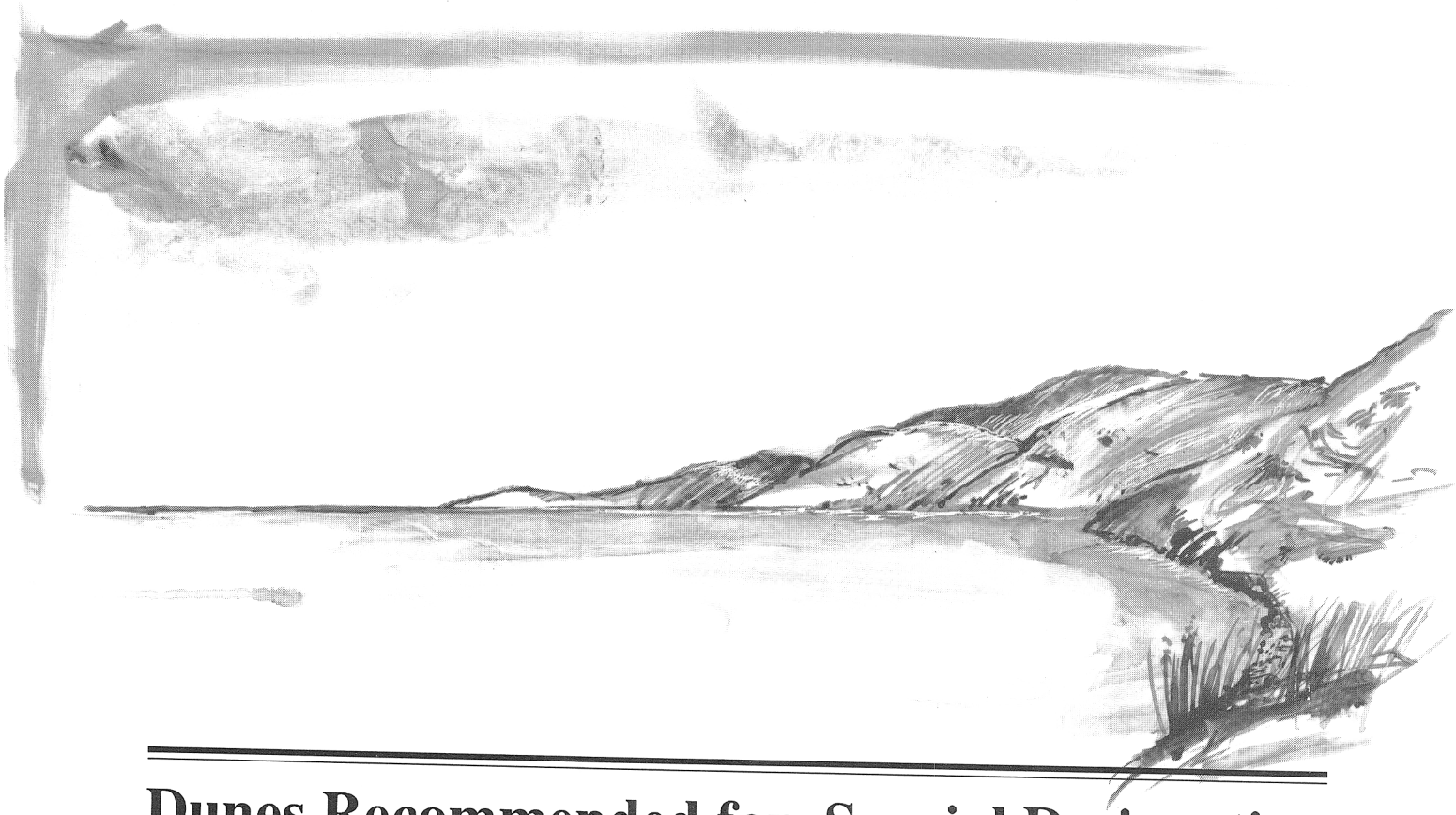
Another aquifer is in the Tuana gravel, which caps the bluffs. It received seepage water from the Bell Rapids Canal until it was abandoned after the 1987 landslide destroyed the pump station. This aquifer is generally on the decline, but one well shows an increased water level. It may be recharging from pond storage in the distribution system, or water from the still-used Fossil Gulch Canal may be flowing south through the ancient stream channels.

Based on the results of our research in 1992, the National Park Service, the irrigation district, and other federal management agencies agreed that the irrigation system is in fact the source of the landslide problem. With this consensus, we are working at an accelerated pace to solve the problem. Solutions being considered include additional canal lining, piping of canal water, de-watering of perched aquifers, and other possible long-term solutions.



Photographic and schematic profiles show the anatomy of the landslides threatening important fossils at Hagerman Fossil Beds National Monument. Research shows that aquifers fed by irrigation canals in the area caused the slippage. The park is working with the irrigation district and other federal agencies to correct the problem.





Dunes Recommended for Special Designation

By Walt Loope, Research Ecologist, Pictured Rocks National Lakeshore

During 1992, Pictured Rocks National Lakeshore took initial steps to evaluate the potential for establishing Grand Sable Dunes within the park as a research natural area. This special designation provides for management of areas that are particularly valuable for research purposes or to maintain biological diversity. A "Dunes Workshop," held in June, gathered information on research natural area designation, design, and management from 15 scientists who have worked in the area. Characteristics of the dunes, ranging from rare plant demography to soil stratigraphy and geomorphology, played prominently in workshop discussions.

The basic physical dynamics of the dune field are understood. Sand supply is derived from steep, wave-cut, lake-facing bluffs composed of glaciofluvial deposits of sand, silt, and gravel. Prevailing landward winds pick up material from the upper third of the bluffs and deposit it inland in a series of dunes. Subsequent behavior of these dunes depends on rates of sand supply and the influences of colonizing vegetation, which vary through time. Sand supply varies with bluff stability, which is related to Lake Superior levels.

Grand Sable Dune's uncommon "perched dunes" afford habitat for a variety of unusual vascular plant species (six state-listed and one federally-listed endangered species). The dunes also contain a surprising variety of grapeferns, some of which are newly described and very restricted in distribution. A leading authority suggests that Grand Sable Dunes contains one of the most diverse and unique *Botrychium* floras in the world. Plant community studies have found that the fates of several rare species are tied to specific disturbance regimes related to sand and silt deposition/deflation. Understanding the dynamic nature of rare plant habitats in the vicinity of Grand Sable Dunes is a key to their conservation biology: How do populations occupying transient habitats persist? How are plant life cycles linked with natural geomorphic dynamism?

Many details of the dune field's Holocene history are unclear and highly relevant to the fates of rare species: What determines periodicity of dune building episodes? How closely are periods of dune building tied to changes in lake level? Recent carbon dating and soil stratigraphy work suggests that the dune field was activated 5500 years ago during the Nipissing stage of the Great Lakes. Subsequent episodes of dune development have been hypothesized at specific intervals during the late Holocene. Sedimentary structures present in the dune field are keys to testing these ideas. Interplay of soils and vegetation dynamism with Lake Superior levels make these studies relevant to global climate change questions.

Long-term studies at Grand Sable Dunes linking rare plant demography with natural cycles of physical disturbance should contribute to the development of management principles that can be applied to the Great Lakes' shoreline.

The concept of research natural area designation was strongly endorsed by the group of scientists convened in June and by park staff. Pictured Rocks is presently preparing a research natural area nomination for Grand Sable Dunes. A management plan will be developed to guide the park in preserving the dunes' unique scientific values while providing for appropriate public use of this striking area.



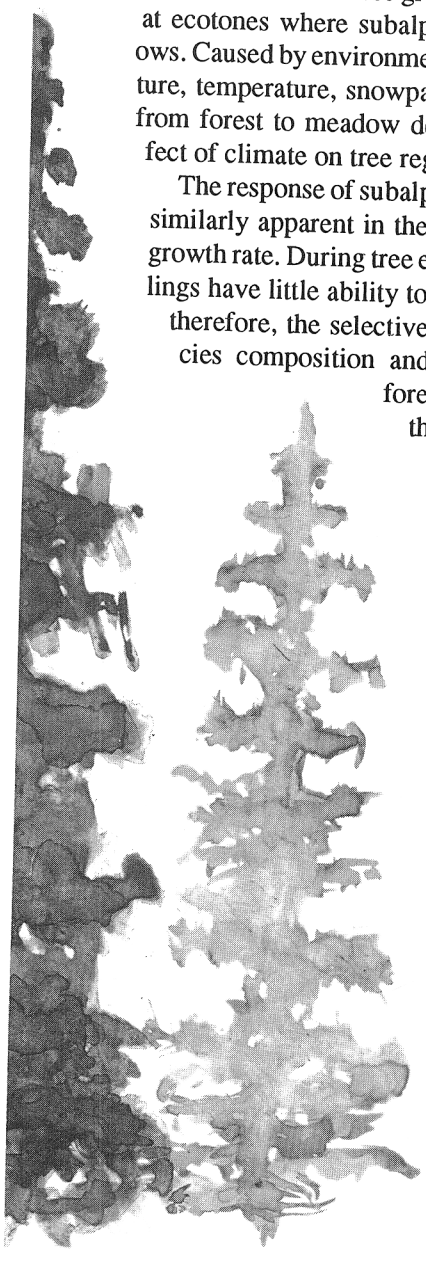
Forests in the Cascade Mountains of the Pacific Northwest Found Vulnerable to Climate Change

By Ronda L. Little, Research Assistant, David W. Peterson, Research Assistant, and David L. Peterson, Research Biologist, University of Washington CPSU

For many years, the forests of the Pacific Northwest were considered to be relatively protected from the effects of global climate change. Warmer coastal air and high precipitation presumably reduced the magnitude of climatic fluctuations. We now know that these forests *are* susceptible to climate shifts. This vulnerability is due to unusually steep regional and local gradients within the overall moisture system, which affect vegetation distribution.

The influence of these gradients is particularly striking at ecotones where subalpine forests border on meadows. Caused by environmental factors such as soil moisture, temperature, snowpack, and wind, this transition from forest to meadow demonstrates the dramatic effect of climate on tree regeneration and growth.

The response of subalpine trees to climate change is similarly apparent in their establishment success and growth rate. During tree establishment, the small seedlings have little ability to buffer climatic fluctuations; therefore, the selective pressure of climate on species composition and relative abundance within forests is especially high during this stage of their life cycle. Yet disturbances such as fire may speed the response of subalpine forests to climate change; with the old trees removed, the subsequent new seedlings have more available resources. Once the new trees are established, their growth rates will reflect relative vigor and ability to compete in the new environment following the disturbance.



Subalpine fir is one of the most common subalpine tree species in the Pacific Northwest. Therefore, climatic changes that influence the establishment and growth of subalpine fir could have a major impact on the distribution and productivity of subalpine forests. We studied establishment of this species near Mt. Rainier at two sites which regenerated naturally following fire 90 years ago; the establishment dates of sample trees at these sites were compared to local climate records. In addition, we determined the effects of climate on growth of mature subalpine fir trees at several sites in the north Cascade Mountains; variations in annual radial growth of trees were compared to annual variations in monthly temperature and precipitation.

Both the establishment and growth of subalpine fir are promoted by warm, dry springs with low snowpack. The influence of summer temperature and precipitation on tree establishment and growth varied among sites, which suggests that local differences in site conditions affect the response of this species to climate. In fact, variations in aspect, soil type, and topography have such a strong influence on the environment of plants that they may produce greater variation in climate response on a local basis than has been predicted on a regional basis. Furthermore, climate may affect tree establishment differently than tree growth. For example, the establishment of subalpine fir is not influenced by autumn temperatures, while the radial growth of mature trees increases during years following warm autumns.

The response of subalpine fir to climate change will depend on seasonal changes in climate. Both tree establishment and growth will improve if less winter precipitation reduces spring snowpack and lengthens the growing season. However, warm and dry summers may result in soil moisture stress and poor establishment, especially in areas with high solar radiation and well-drained soils.

Are these potential changes in the growth and establishment of subalpine fir a concern to National Park Service resource managers? The answer is a resounding "yes" if we take a long-term view of management issues. Recent scientific evidence shows that there has been an increase in establishment rates and growth of several subalpine conifer species in western North America during the last century. High elevation landscapes and the rate of "natural" processes could be quite different in the future if there is an accelerated rate of climate change.



Robert Stottlemyer, Director's Award for Research

Robert Stottlemyer, Research Ecologist with the Water Resources Division, received the 1992 Director's Award for Research. Stottlemyer has served the National Park Service in research, management, and advisory capacities, but has always maintained an active research program. Since 1976, he has been the author or co-author of 133 publications, reports, and abstracts in the field of long-term studies on forest vegetation, nutrient dynamics, biogeochemical cycling, and global climate change. In 1992, five manuscripts were published in peer-reviewed journals and seven manuscripts accepted for later publication. Stottlemyer has conducted research in eleven parks. In addition to research in national parks, he is currently participating in cooperative long-term forest research with the U.S. Forest Service in Fraser National Forest, Colorado. Besides being of importance to the national parks, Stottlemyer's research has established him as a highly regarded and respected leader in his field. His long-term dedication to the National Park Service and to his field of research clearly make him worthy of recognition.

Neotropical Migratory Bird Stopover Ecology Research Contributes to Conservation Program

By Ted Simons, Director, University of Virginia CPSU

Neotropical migratory birds perform the remarkable feat of making much of the Western Hemisphere their home. Over 80% of North American birds are migratory during some part of their annual cycle and about half of those species migrate to the Neotropics. They include many well-known species of songbirds, waterfowl, shorebirds, and birds of prey.

We have known for some time that some of the migratory bird species are in trouble. Golden-cheeked, Bachman's, and Kirtland's warblers are listed as endangered species, as are the Least Bell's and black-capped vireos. Population reduction problems can usually be traced to extremely limited and specialized breeding and/or wintering habitat; it is also generally believed that the populations of these birds have been low historically.

More recently a larger problem has been detected. The U.S. Fish and Wildlife Service has conducted an annual U.S. Breeding Bird Survey since 1966. Population trends derived

from the survey of Neotropical migrants from 1978-1987 indicate that 71% of the species classified as Neotropical migrants declined during the period. Of the 44 species showing negative trends, 20 exhibited statistically significant declines. Declines for some species, such as the bay-breasted warbler, have been precipitous, averaging 16% per year. More typical are species like the Kentucky warbler and painted buntings, whose populations are decreasing at rates of 2-3% per year.

Additional information has come from several long-term population studies conducted at protected sites in the eastern United States. The best and most dramatic data available come from 40 years of research at Rock Creek Park, one of the largest natural urban parks in the world, located in the center of Washington, D.C.

Over a third of the 15 Neotropical migrant species present in Rock Creek in the 1940s have now disappeared from the park. Numbers of other migrants have dropped by 80-90%, and overall breeding densities have fallen by half. Where once 60-80% of the park's breeding birds were migrants, now migrants comprise less than 40%. In contrast, resident and short-distance migrants still breed in numbers similar to those of 40 years ago, and none have disappeared.

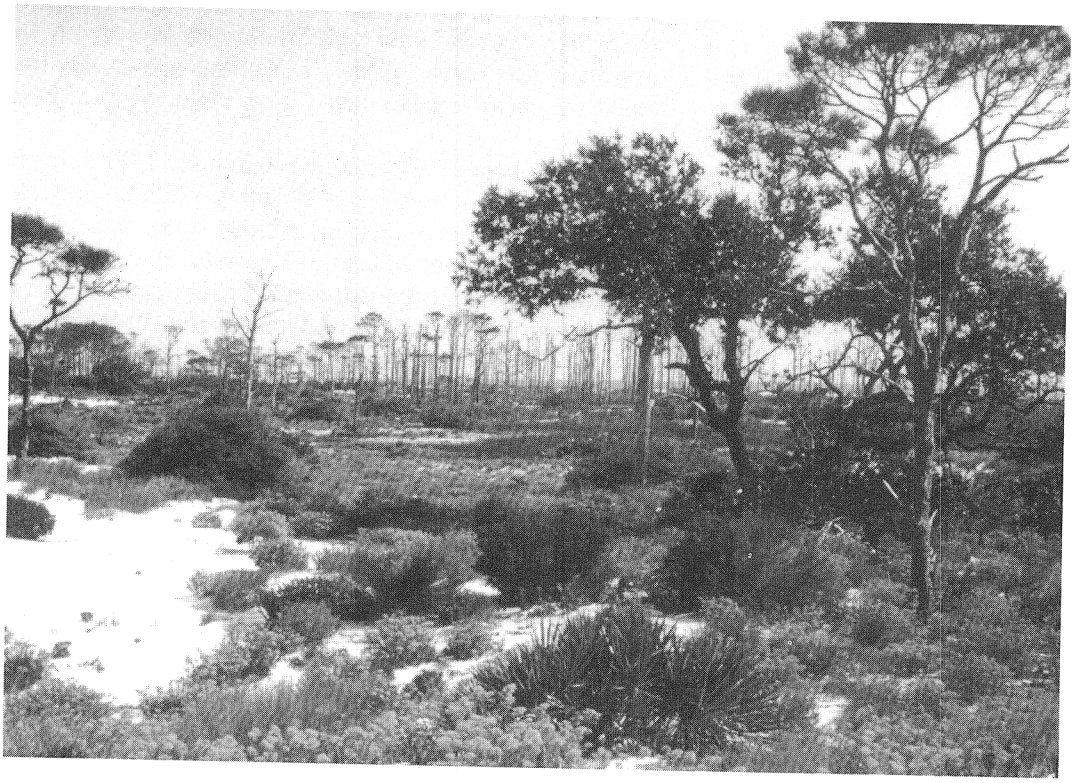
Although more research is necessary to fully understand the scope and magnitude of these declines, there is now no question that they are occurring. Although population declines are probably the result of a constellation of factors, habitat changes in both the breeding and wintering grounds are thought to be largely responsible. Forests in the U.S. are becoming fragmented, monotypic, or disappearing altogether, providing little habitat for Neotropical migrants. Temperate forest habitats are resilient, however, and management could make a positive difference. The outlook in the tropics is worse. Logging and land clearing for agriculture and ranching is taking 1-4% of forested lands per year and the rate is rising. Unfortunately, unlike temperate forests the recovery of large tracts of cleared tropical forests will probably be poor due to loss of soil nutrients and soil compaction.

The migratory period represents the least understood link in the annual cycle of these birds. My colleagues and I have been studying the stopover ecology of Neotropical migrants at East Ship Island, Mississippi (part of Gulf Islands National Seashore), and at Peveto Beach in Southwest Louisiana for the past six years. It is becoming apparent that these stopover sites may be critical to any conservation strategy for Neotropical migrants.

The barrier islands and coastal woodlands along the Northern Gulf Coast are natural concentration points for migrants; they are often the first landfall for birds returning to North America in the spring and the jumping off point for the return trip to tropical wintering grounds. In our study, we net about 3000 birds at each site each spring. Birds are weighed on an electronic scale, measured, banded, and released. Results provide an index of the birds energetic condition, which we can then relate to a variety of other factors, such as weather conditions, length of stopover, and behavior.

We have found that the vast majority of birds stopping over along the Gulf Coast have exhausted their energy reserves. Overall, the percentage of birds with no fat residues is higher in recaptured birds than in those which are not recaptured, suggesting that birds with sufficient energy reserves continue migration sooner or select better habitats. The length of stopover is low (1-2 days) although birds at Peveto tend to stay longer than at East Ship Island. We also

(*Continued*)



Typical Neotropical migratory bird habitat along the Northern Gulf Coast. These areas provide stopover sites for migrating birds, representing a critical phase in the annual cycle of these birds.

found that birds gained weight faster at Peveto, presumably a reflection of greater prey availability at the site.

In summary, our work to date indicates:

1. Stopover represents a critical phase in the annual cycle of Neotropical migrants.
2. These birds show a wide range of energetic and ecological requirements during stopover. These are a function of the condition of the birds when they arrive, weather, predators, and other factors.
3. Stopover habitat quality is variable.

We hope to begin to understand the broader habitat requirements of migrants during stopover through some recently begun fieldwork involving a combination of mapping and censusing designed to determine the relative importance, status, and trends of stopover habitat along the Northern Gulf Coast. To fully understand the conservation needs of Neotropical migrants we will have to gain a much better understanding of their ecology and habitat requirements during migration. Clearly, the loss of suitable stopover habitat could create a veritable black hole for migrants and contribute substantially to future population declines.

Clearing the Air on Ozone Impacts in the Sierras

By Judith E. Rocchio, Air Quality Coordinator, Western Region

The San Joaquin Valley air basin, one of the most polluted areas in the country, lies adjacent to the central and southern Sierra Mountains. Ozone levels in the mountains frequently have higher peaks than those in urban areas in the Valley. Daily average ozone levels in the Sierras also exceed most urban areas in California; ozone values in the Sierras at night remain high as a result of the absence of agents which deplete ozone levels in urban areas at night. Ozone generated from automobile emissions reacting with sunlight moves from the Valley into the Sierras each day. The situation will likely become worse with the predicted 43% population increase in the San Joaquin Valley by 2005.

The National Park Service, the U.S. Forest Service, and the California Air Resources Board are cooperating in a project designed to address the problem of ozone air pollution in the Sierras. Project FOREST, the Forest Ozone REsponse STudy, will provide federal land managers (FLM's) and California state air resources regulators with information regarding ambient ozone concentrations and visible ozone air pollution injury to ponderosa and Jeffrey pines, two sensitive western pine species in the Sierras. Project FOREST includes ten study sites in five National Forests and three national parks in the central and southern Sierras, covering nearly 400 linear miles. Each site includes an ambient ozone monitor, a meteorological tower, and three pine tree plots. The study sites are located at elevations between 4,000' and 6,500'. Two full years of ambient ozone and foliar injury data have been collected in 1991 and 1992, the first two years of this five-year study.

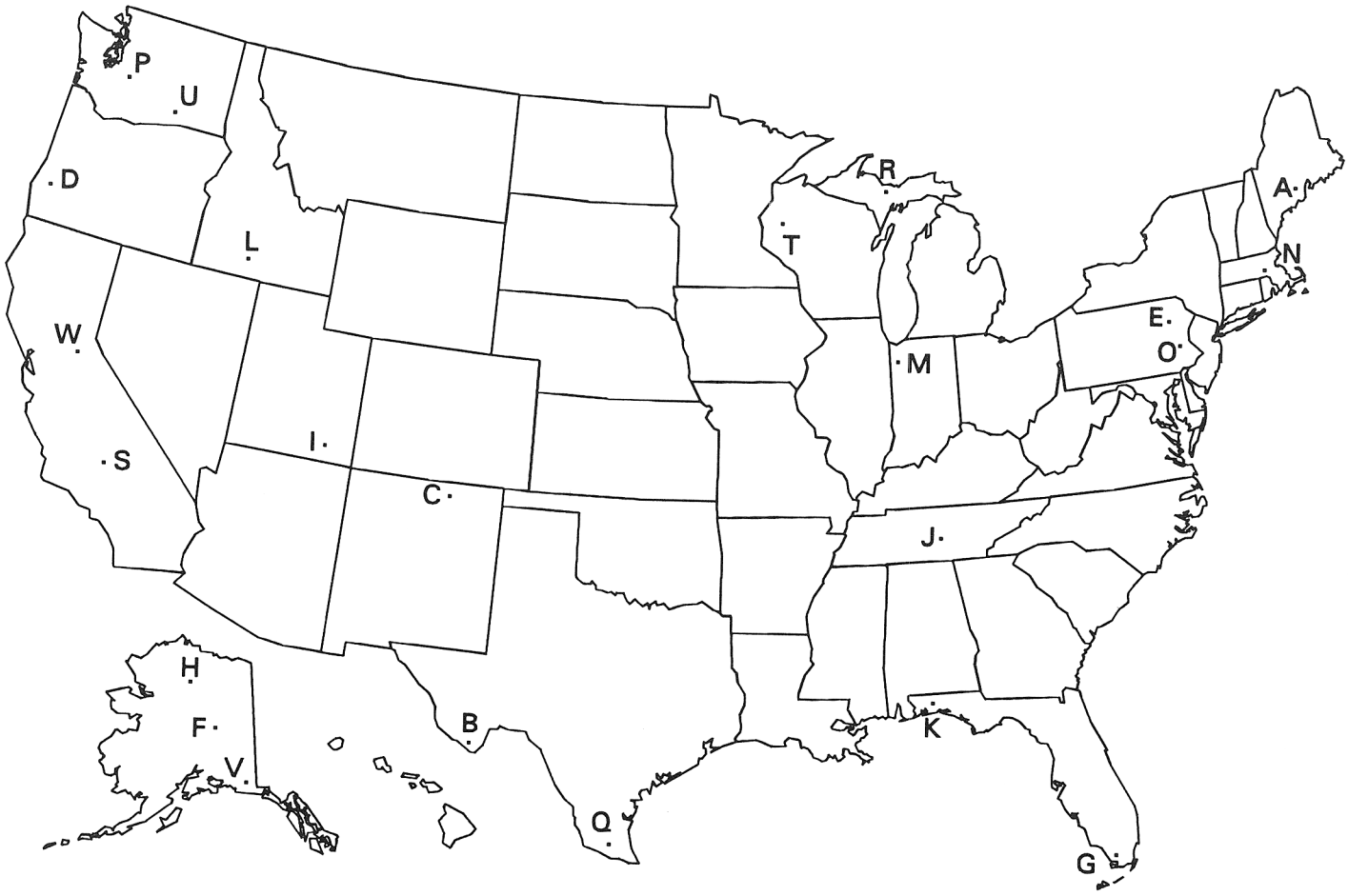
One important objective of the study is to identify the total amount of ozone exposure and related foliar injury to ponderosa and Jeffrey pines in the Sierras. Three pine plots of 50 trees each were located within three miles of each ambient monitor. The western pine method (WPM), used in this study to quantify the extent of visible ozone injury to pines, was developed by a joint agreement with the Park Service and the Forest Service to provide a consistent interagency monitoring method. The WPM index maximum ozone injury score of 100 indicates an extremely affected tree or plot. An index value of zero, the minimum injury score, indicates no ozone injury present.

Foliar injury data collected in August and September 1991 reveals the presence of ozone injury at each of the 30 pine plots surveyed. Giant Forest Plot #1 in Sequoia National Park recorded the highest injury index plot score of 34 and the highest 3-plot average of 29. Camp Mather plot #1 in Yosemite National Park reported the lowest plot injury score of 6.6. Shaver Lake reported the lowest 3-plot average of 9 in the Sierra National Forest. The 3 southern-most sites have the highest degree of injury; the 7 remaining sites are similar and show less injury. Other studies have shown that tree health may be affected by ozone injury index values of 50 or higher.

Ambient ozone data collected during the 1991 summer season show levels in excess of 90 parts per billion (ppb), the human-health-based California ambient ozone standard, at all sites except Camp Mather in Yosemite. Foliar injury to pines occurs at concentrations above 50 to 60 ppb. Mt. Home reported the greatest number of exceedances; 122 in June, 74 in July, 71 in August, and 112 in September.

The preliminary result of this study should be a warning to federal land managers and California State regulators: elevated ozone levels in the Sierras are currently affecting trees at all locations monitored in this study. With the projected increase in population for the San Joaquin Valley these impacts will likely increase over time. Ambient ozone concentrations regularly exceeded the state human-health-based standard. We must not allow growth and development in the San Joaquin Valley to occur at the expense of human health and the health of adjacent forests in the central and southern Sierras.

National Park System Units Represented in 1993 Highlights of Natural Resource Management Report



A. Acadia NP
B. Big Bend NP
C. Capulin Volcano NM
D. Crater Lake NP
E. Delaware Water Gap NRA
F. Denali NP&Preserve
G. Everglades NP
H. Gates of Arctic NP&Preserve
I. Glen Canyon NRA
J. Great Smoky Mountains NP
K. Gulf Islands NS
L. Hagerman Fossil Beds NM
M. Indiana Dunes NL
N. Minute Man NHP
O. Morristown NHP
P. Mount Rainier NP
Q. Padre Island NS
R. Pictured Rocks NL
S. Sequoia & Kings Canyon NP
T. Saint Croix NSR
U. Whitman Mission NHS
V. Wrangell-St. Elias NP
W. Yosemite NP