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Integrating Research and Resource Management

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Reopening a Niche at Badlands National Park: the Black-footed Ferret

Prairie dog conservation, not complex biology, holds the key to recovering this Great Plains predator

By Glenn E. Plumb, Bruce Bessken, and Paul Marinari

Do you remember when your science teacher brought out the "mystery" box, the one with the hole in the side, and asked you to stick your hand inside and identify an item only by touch? You had no idea what might be encountered. Yet, once you grasped the object, your curiosity peaked and the challenge became an exciting opportunity! Likewise, biologists and resource managers in Badlands National Park, South Dakota, had been groping for years to find a way to restore one of North America's most endangered terrestrial mammals to its prairie habitat. Finally, after 6 years of preparing for reintroduction, our moment of discovery and triumph came last fall with the arrival of the first black-footed ferrets *(Mustela nigripes)* to be seen in the park in over 25 years (fig. 1).

Figure 1. The first black-footed ferret to be set free in the 1994 Badlands National Park reintroduction eyes the open door of its release cage moments before leaving to freedom.

Background

The black-footed ferret's nocturnal habits do not lend the species to ready study. For an animal first described in 1851 by Audubon and Bachman, and which once ranged from southern Saskatchewan to northern Mexico, practically all ecological information comes from two small populations in South Dakota and Wyoming that went locally extinct after intense, but limited, study. This animal is a highly specialized predator that depends on a single type of habitat–prairie dog *(Cynomys ludovicianus)* colonies. A member of the Mustelid family, the black-footed ferret uses prairie dog burrows for shelter, family rearing, escape from predators, and access to its primary prey, the prairie dog.

The ferret was listed in 1967 as a federal endangered species and in 1978 as a South Dakota endangered species. The

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As fire season begins, look for an article on prescribed natural fire management in Glacier National Park and a fire history reconstruction study near Bandelier National Monument. We will also delve into the crossover area between natural and cultural resource management with an article that details the associations between rising and falling levels of Yellowstone Lake and Paleo-Indians. The second in our series on NBS science centers is presented next time and will be a profile on the Midcontinent Ecological Science Center in Fort Collins, Colorado. Also, vegetation mapping on a landscape scale in the Pacific Northwest, grouse in Acadia National Park, MAB notes, and a book review by Gerry Wright.

Backyard and Beyond

This issue takes us around the country (and around the globe) sampling research and resource management projects from Alaska, the Great Plains, the Virgin Islands, and Gulf Coast, to the eastern piedmont, the desert southwest, and the Rocky Mountains. In several instances the articles point to research applicability beyond the parks or demonstrate the strides we have made in forming partnerships beyond our own agency. For example, satellite radiotelemetry studies (described on page 20) revealed the impressive long-distance falcon migration link between Alaska, Russia, and Argentina. The research technique has worldwide utility and demonstrates the added complexity of preserving certain bird species that are shared international resources. The story on migratorial hawksbill sea turtles at Buck Island Reef National Monument in the Caribbean used similar research techniques, also relied on interagency cooperation, and makes very similar conclusions to the falcon story.

The lead article on ferret reintroduction to Badlands National Park can be viewed as a triumph in wildlife management where legislators, biologists and administrators from several state and federal agencies, and private conservation concerns rallied to return this Great Plains predator to the wild. But it also points out that, while varied, recovering species often has as much to do with bringing people together as using complex biological techniques.

Like the ferret article, others describe resource impacts and solutions that are tied to sources outside park boundaries. Water Resources Division Wetlands Program Leader Joel Wagner describes that at times external threats to water resources can be challenged by legislation designed to help us carry out our mission. Virgin Islands soil erosion and subsequent coral reef impacts are preventable, as researchers Lee MacDonald and Donald Anderson explain, but only with the involvement of islanders living outside the park. In each of these cases, research provides some answers, and the course to be taken in implementing the recommendations requires management skill.

On my mind is seeing the National Biological Service (NBS) succeed in providing us with high quality service. To this end, we begin a series of articles to help us understand how the NBS is organized and how to go about requesting technical assistance. This issue's introductory piece describing science centers in general will be followed next time, and every so often over the next couple of years, by individual science center profiles. The profiles will show the kinds of skills and park-relevant research conducted by the NBS and should help us make the appropriate new contacts for assistance. As a starting point, the science center list on page 31 may prove to be a useful reference in getting to know the available NBS products and services.

Rounding out the selections, paleontologist Vince Santucci sets the record straight on Gettysburg dinosaur tracks, a natural resource that has been misinterpreted for decades. Finally, while research is usually conducted in response to a particular need, its use is sometimes far greater than we could ever imagine. University of New Mexico Biologist Bob Parmenter relates a fascinating story about a connection between his baseline resource study data collected at Pecos National Historical Park and the recent hantavirus epidemic. What begins in parks to find answers to management questions often takes us elsewhere.

Jeff

Yellowstone Computerizes Rare Animal Report System

By Mark Johnson

Before the 1930s, Yellowstone National Park visitors, staff, and researchers recorded rare animal observations primarily in journals, Army scout diaries, Army station records, and administrative reports. During the 1930s, the agency began a more systematic system, with wildlife observations being recorded on wildlife observation cards. The system was further refined in 1986 with the implementation of the rare animal sighting form.

Though these observations contained very important information, the system made data analysis, sorting, retrieval, and summaries very tedious and time-consuming. In an effort to make data analysis more efficient, the Yellowstone Center for Resources updated and computerized the rare animal sighting report system in 1993.

The new computer database breaks down each sighting into 56 information fields that can be quickly sorted and retrieved. It can also be used in conjunction with the park GIS and is compatible with the U.S. Fish and Wildlife Service wolf reporting system and the National Heritage Project conservation data system.

The new program will make the sighting reports much more usable for research and management biologists, resource management coordinators, visitors, and contract researchers. For example, the U.S. Fish and Wildlife Service can use the new system as a tool to help determine if and when wolf packs become established in the Yellowstone ecosystem.

The new database consists of more than 1,000 records from 1986-95, ranging from species as small as amphibians and flying squirrels to as large as gray wolves and mountain goats. Wildlife observation records before 1986 will still be available for use manually, through the earlier wildlife observation card system.

Mark Johnson is a Wildlife Veterinarian with the Yellowstone Center for Resources.

Regional Highlights

North Atlantic

Morristown National Historical Park, New Jersey, is the recipient of a $10,000 grant from the National Park Foundation. The park will use the money to conduct its first herbaceous plant survey. Working under a principal investigator contracted through Rutgers University, Garden Club of America volunteers will undertake a systematic inventory of all herbaceous species found in the park. The information acquired from the inventory will assist the park in determining the effect that deer browsing and the spread of exotic species are having on its herbaceous plant population.

Midwest

The West Branch Wapsinonoc Creek, which flows through Herbert Hoover National Historic Site in West Branch, Iowa, overflowed its banks several times during 1993. On August 16, the tributary damaged NPS facilities and property in one last, severe flood. At NPS request, the Iowa District of the U.S. Geological Survey (USGS) Water Resources Division conducted a flood risk analysis for the tributary through the historic site.

The analysis confirmed park vulnerability to periodic flooding. On August 16, 1993, the worst day of flooding, the tributary flowed at a peak of 1,650 cfs (cubic feet per second), whereas the capacity of the tributary in the park is limited to 650 cfs. The reading corresponds to a flood frequency discharge of a 25- to 50- year event. Several structures are at risk of flooding, especially the maintenance building, which could be flooded as often as every 10 years. Fortunately, the main floor elevations of the Hoover Library and birthplace cottage are above the 100-year flood elevations, although only by less than a foot.

This flood analysis demonstrates that the USGS is responsive to short-notice management needs for information that can be used in making informed management decisions. We hope that others will explore using their services in this capacity.

Reference

Einhellig, P.E. 1994. Flood analysis, West Branch Wapsinonoc Creek tributary, Herbert Hoover National Historic Site, West Branch, Iowa. U.S. Geological Survey-Iowa District, Water Resources Division.

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Bald eagles symbolize not only the United States of America, but also American environmental quality. Researchers recently developed a protocol for using the bald eagle as a Great Lakes air quality indicator species (Bowerman et al.). The Great Lakes Protection Fund provided grants to develop a protocol through two coordinated research and management studies: a broad, Great Lakes Basin study, and an intensive, localized study of northern Wisconsin.

The basinwide project assessed habitat quality, the role of environmental contaminants, and population dynamics of nesting bald eagles across the Great Lakes Basin. Researchers determined that bald eagles build nests primarily in white pines, except around Lake Erie where they use cottonwoods. Although potential nesting habitat exists along the shorelines of all the Great Lakes, it primarily exists along lakes Huron and Superior. Habitat availability, however, may limit the Lake Erie subpopulation, which has little unoccupied habitat and a high density of nesting eagles. Concentrations of p,p'-DDE or PCBs (polychlorinated biphenyls), but not mercury or selenium, were significantly (and inversely) correlated with regional reproduction and success rates. Concentrations of organochlorine compounds primarily regulate bald eagle reproduction levels along Great Lakes shorelines, whereas bird density-dependent factors regulate productivity in the relatively uncontaminated interior areas.

The intensive local study in northern Wisconsin assessed the role of food availability, weather, and contaminants on bald eagle productivity. Bald eagles nesting on the Lake Superior shoreline in Wisconsin experience significantly lower reproductive rates than those nesting more than 8 km (4.9 mi) *inland* from the Wisconsin lakeshore. The weight of evidence suggests that the most likely cause of lesser productivity on the Wisconsin Lake Superior shoreline is low food availability, with greatest effects measured in bald eagle pairs with two young; however, DDE remains a possible contributing factor.

The bald eagle biosentinel protocol appears to have great utility for organizations that wish to monitor ecosystem components, such as water quality. The state of Michigan has formally adopted the protocol to assess Great Lakes water quality. Later this year, the National Park Service and other federal agencies may adopt the protocol, too.

Reference

Bowerman, W.W., M.W. Meyer, and J.P. Giesy. 1994. Use of bald eagles as ecosystem monitors of Great Lakes water quality: development of a biosentinel protocol. A companion report to Great Lakes Protection Fund Final Reports for Grants # RE792-3092-1 and # RE792-3092-2.

Western

Staff from the regional office and Redwood National Park presented a paper at the annual American Geophysical Union meeting held in San Francisco. The paper, "Pool development and sediment loads, Redwood Creek, California," described a sequence of pool destruction and partial recovery in a river following catastrophic flooding and sedimentation. Pools are an important rearing and hiding habitat for salmonids, and population densities are associated with pool availability. This study documented the recovery of pools over several parts of the watershed for a 20-year period.

Mid-Atlantic

Both Gettysburg National Military Park (NMP) and Eisenhower National Historic Site (NHS) were established to honor and preserve significant historic events. Visitors have the opportunity to learn about these events, in part, due to management objectives adopted to maintain the historic landscapes of each area. However, staff now experience difficulty maintaining the agricultural character of these parks, because of significant and sometimes total crop losses caused by white-tailed deer feeding. In addition, deer browse on tree seedlings, which threatens the perpetuation of the historic woodlots.

Addressing these problems, park and regional staff released a draft environmental impact statement late last November proposing white-tailed deer management. The draft was completed after research documented the effects of deer browsing on the historical resources of the parks. According to the April 1994 mean population estimate, 853 deer occupied the 11-square-mile study area. The preferred alternative described in the environmental impact statement proposes reducing deer numbers to 80 by increasing hunting opportunities outside the parks and

authorizing agents to shoot deer in the parks. The deer population would be maintained at or near this density by these methods. Reproductive intervention (i.e., contraception), when approved for deer population management, could also be used in the maintenance phase. The final statement, which should be completed this summer, will respond to any comments received. Management action could occur as early as October 1995.

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Assateague Island National Seashore, Maryland, has completed a draft environmental assessment that evaluates the effects of implementing a program to manage the size of the feral horse population there. Feral horses impact park natural resources. The National Park Service proposes to implement a fertility control program that uses porcine zona pellucida immunocontraception. The horse population would be reduced to approximately 150 animals and would be maintained at these levels. Comments will be considered to determine whether to proceed with the proposed management alternative or prepare an environmental impact statement.

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A set of three technical reports by Virginia Tech investigators are available from Richmond National Battlefield Park, Virginia. Technical Report NPS/MARRICH/NRTR-94/059, Fire History and Fuel Loads of Upper Coastal Plain Forests, presents the results of a study that researched the history and influence of fire on the park, determined the loading of dead and down forest fuels in six forest cover types, and examined relationships between the fuels and the vegetation to create fuel load prediction equations. The park forest cover types are described in Technical Report NPS/MARRICH/NRTR-94/060. Included in this report are discussions of specific vegetation management recommendations for meeting park management objectives. The form and function of park forested wetlands are the subject of the third report, Technical Report NPS/MARRICH/NRTR-94/061. During 1992, researchers conducted an inventory to determine the extent of jurisdictional wetlands within the park. They mapped each wetland, inventoried its vegetation, described soil features, and measured average monthly water table depth.

The species composition and structure of plant communities for two forested areas in Hopewell Furnace National Historic Site, Pennsylvania, are described in Technical Report NPS/MARHOFU/NRTR-94/062. Scientists measured trees, shrubs, seedlings, and ground cover from 1991-92 using 30 sampled 20 x 20 m (65.6 x 65.6 ft) plots in each historic stand. Fifteen of each set of 30 plots contain a central fenced 2 x 2 m (6.6 x 6.6 ft) subplot. The results of this study provide a profile of current conditions and background data for future long-term monitoring to determine the effects of feeding by white-tailed deer on forest regeneration. Similar plot systems are also in place at Gettysburg NMP and Valley Forge National Historical Park.

From 1984-86, researchers developed a multiparameter monitoring system emphasizing measurements, as opposed to ratings, and employed it in documenting and evaluating changes in resource conditions on 179 river campsites within Delaware Water Gap National Recreation Area, Pennsylvania. Findings from this survey revealed some problems and resulted in a number of management recommendations with respect to minimizing resource impacts being offered and implemented. Research staff refined monitoring procedures through additional research and reapplied them in 1991. Jeffrey L. Marion presents results in Technical Report NPS/MARDEWA/NRTR-94/063 that show a substantial reduction in all resource impacts assessed by the campsite monitoring programs. In particular, the total area disturbed by camping declined 50% from 1986-91. The report offers additional recommendations and options for management consideration.

Natural Resources Report NPS/MAR/NRR-94/003 describes a case study of public involvement in scoping for environmental impact assessment. The report presents the process used by Gettysburg NMP and Eisenhower NHS to obtain public comment regarding the intent to manage the white-tailed deer population in the parks. Managers chose to involve the public and obtain input in a number of ways, including the use of an informational meeting and a public meeting where they followed the nominal group process as opposed to the formal hearing format. The nominal group process involved soliciting comments from citizens using a structured small group technique in which participants of each group responded to a predefined nominal question. The result of the nominal group meetings was a series of prioritized lists of concerns.

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Accelerated erosion, sedimentation, and associated water quality impacts are ongoing processes at Colonial National Historical Park, Virginia, that affect natural and cultural resources. Additionally, stormwater management problems result in concentrated runoff from parking lots and roadways in and near the park and cause very high rates of channel erosion in gullies and streams along the James and York Rivers. To study these problems, the park recently arranged for North Carolina State University School of Forest Resources to begin an erosion and sedimentation study. Under the cooperative agreement, the investigators will develop a methodology for erosion and sedimentation management, using GIS, to be tested at Colonial and later applied at several other national park system areas. The study should identify area sediment sources, assess erosion severity, and lead to reduction of both sedimentation and erosion in and near the park.

ROCKY MOUNTAIN

The Environmental Protection Agency (EPA) has initiated a new program to help prevent pollution from occurring in large geographic areas. A twist on the earlier agency focus of cleaning up polluted sites, the new program emphasizes prevention and is geared to foster healthy habitats and encourage ecosystem management. The new program led EPA staff in Denver to explore new ways of doing business with its partners on the Colorado Plateau.

More than a year ago, the Denver EPA office, which was working in national parks teaching pollution prevention techniques, suggested that we take a broader approach on the Colorado Plateau. Subsequently, the NPS Rocky Mountain Region and EPA Region 8 negotiated an in-

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teragency agreement that encourages a broader approach for defining and managing healthy, sustainable ecosystems. We signed the Colorado Plateau Ecosystem Partnership Project agreement in August 1994.

Plateau residents are concerned about socioeconomic changes occurring in their neighborhoods. Newcomers seeking alternative lifestyles have shifted demographic trends, and basic economic activities have shifted to service the increasing number of tourists and recreationists. The growth of small plateau communities has placed demands on the ecosystem that may alter its health. Ironically, the exquisite landscape may be harmed by the very people who have come to enjoy it.

Recently joining the NPS-EPA effort are the NBS Midcontinent Ecological Science Center in Fort Collins, Colorado, and the NBS Field Research Station in Flagstaff, Arizona. Both organizations bring special expertise in helping to understand the dynamics of the Colorado Plateau. As part of the partnership, they will provide a clearinghouse function on existing data and conduct original research.

The Flagstaff personnel will help establish a framework to gather and disseminate data and information of use to all plateau researchers, residents, and managers. The clearinghouse function is needed because several plateau studies and inventories are underway simultaneously, often with groups unaware of near-duplicate efforts. Transferring data and sharing research findings is also an important component of the project. Staff will contact federal agency researchers and land managers, researchers in the academic community, tribes, communities, and individuals with plateau knowledge or project interest.

The staff in Fort Collins will gather information and develop models to help understand changing demographics, political culture, institutional frameworks, and economics. Understanding how we interact and make decisions is critical in finding the best means to sustain an ecosystem and the local social and economic environment.

A third effort is underway toward that understanding. The Colorado Plateau Forum is a gestating effort to locate a nongovernmental or special interest voice to represent the whole Colorado Plateau. The forum was initiated by the Western Area Power Authority and quickly joined by representatives of the Grand Canyon Trust, Bureau of Land Management, U.S. Forest Service, tribes, local communities and governments, Northern Arizona University, the National Park Service, and the Environmental Protection Agency.

The organization held a town hall meeting, endorsed and partially supported by the Colorado Plateau Ecosystem Partnership, in early March in Moab, Utah. Participants discussed regional commonalities, landscape changes, and the future of the Colorado Plateau.

The partnership continues to seek collaborators in the expanding effort to find broad solutions to what may seem like local problems. But as scientists have been saying since at least the 1930s, we must act locally while thinking globally in our efforts to understand nature's interconnections.

For more information on the Colorado Plateau Ecosystem Partnership Project contact Peggy Lipson or Bob Spude at the Office of Ecosystem and Strategic Management, Rocky Mountain Region, National Park Service, 12795 W. Alameda Parkway, Denver, CO 80225.

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Yellowstone National Park in cooperation with the Montana Air Quality Bureau and the NPS Air Quality Division recently installed air monitoring equipment at the West Yellowstone park entrance station and in the neighboring town of West Yellowstone. The equipment helped to quantify air pollutant concentrations in these areas. Dispersion modeling using snowmobile exhaust emissions estimates and local weather conditions showed the potential for exceedances of the National Ambient Air Quality Standard (NAAQS) for carbon monoxide (CO) near the park entrance and along park roadways during periods of high snowmobile traffic. The NAAQS for CO is 35 parts per million (ppm) for a 1-hour average or 9 ppm for an 8-hour average.

Air Quality Division staff installed CO and particulate monitoring equipment in mid-January and ran the tests through February 20 (for CO) and March 7 (for particulates), respectively. Data collected east of the park entrance showed air quality concentrations well below national standards for both CO and particulate matter. The maximum 1-hour CO concentrations through that period were less than 10 ppm. However, the worst case conditions (high snowmobile traffic with stable weather conditions) were not observed during the study period. Certainly, the potential for high carbon monoxide concentrations does exist near the entrance and along park roadways during high traffic periods (more than 300 snowmobiles per hour).

Most of the pollution measured at the west entrance station is directly attributed to snowmobile activity. Concentrations were highest in the mornings between 8 A.M. and noon when snowmobiles entered the park and in the late afternoon between 4-6 P.M. when snowmobiles returned to town. During other times, air pollutant concentrations were very low.

Although the measurements were legally acceptable, the park took actions this winter to reduce air pollution from snowmobile emissions. For example, the park opened an express lane at the west entrance during peak visitation periods. Staff also requested snowmobile operators to turn off their engines to reduce exhaust emissions while idling near the Madison Junction warming hut. Finally, the park encouraged operators to keep their snowmobiles in proper working order to minimize pollution. The park also sold entrance passes in advance to tour groups to minimize delays and to reduce emissions near the entrance station.

PACIFIC NORTHWEST

As indispensable as GISs are for resource management applications, they can create problems for regional applications when similar data types are coded differently in different parks. For example, Mount Rainier, North Cascades, and Olympic National Parks use different conventions for coding trail data, and Crater Lake plans to develop this data layer in the future. Some amount of standardization would be desirable, especially when data are consolidated for regional uses.

Park and regional GIS specialists recently met to discuss standards for data theme names and attribute definitions. The various methods for coding the same data result from user needs at the various parks. If needs are different,

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A NEW PUBLICATION ON MIgratory shore and upland game bird (MSUGB) management is available, free of charge, to wildlife managers and researchers. The International Association of Fish and Wildlife Agencies has recently published Migratory Shore and Upland Game Bird Management in North America. This book is an updated version of their 1977 publication entitled, Management of Migratory Shore and Upland Game Birds in North America. The 1977 version was updated because substantial changes had occurred in the status of several MSUGB species and important new published literature had become available since 1977. For those NPS units that manage one or more of these species, this book can provide a wealth of material. The book covers 14 species: mourning dove, white-winged dove, white-tipped dove, band-tailed pigeon, sandhill crane, American woodcock, common snipe, American coot, common moorhen, purple gallinule, clapper rail, king rail, Virginia rail, and sora.

Each chapter covers a single species and is written by one or more authors having years of experience studying that particular species. Chapters are, for the most part, similarly organized. As an example, chapter seven discusses the biology and management of the American woodcock, Scolopax minor. This chapter begins with a description of the species and provides methods for aging juveniles and adults. It continues with life history information on spring migration, courtship, nesting, fall migration, and winter survival. Discussions on breeding and winter habitat use, distribution and abundance, harvest data, and management and research needs round out the chapter. The biggest drawback with this new publication is the decision to exclude nonhunted species. This means that none of our 40 or more migratory, breeding, nongame species are included.

If interested in obtaining a copy of this book, send requests to MSUGB Book, Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, Campus Box 218, Kingsville, Texas 78363.

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Results of published studies vary on which live traps are most effective in capturing small mammals. An unpublished M.S. thesis by Sonia Najera of New Mexico State University compared the effectiveness of Havahart and Sherman live traps in capturing lightweight rodents. Using 7.5 x 9.0 x 23 cm Sherman live traps (2.9 x 3.5 x 9.0 in) and 7.6 x 7.6 x 25.4 cm Havahart live traps (3.0 x 3.0 x 9.9 in), New Mexico biologists set traps in alternating sequence in 50-trap grids or transects. Traps were spaced 5 m apart (16.4 ft) and placed in moist-soil impoundments, sloughs, croplands, and along canals and ditch banks. The biologists set all the traps so that a minimum amount of pressure on the treadle would trigger the release mechanism, allowing capture of lighter weight rodents. After 600 trap nights, they moved the traps.

The authors trapped 4,889 rodents (including individuals of nine species) during 29,259 trap nights. The most common species captured (including recaptures) were white-footed mouse (*Peromyscus leucopus*–2,141), cotton rat (*Sigmodon hispidus*–2,127), western harvest mouse (*Reithrodontomys megalotis*–267), and meadow jumping mouse (*Zapus hudsonius*–164). Havahart live traps caught more mice weighing under 30 grams (1 oz). Conversely, Sherman traps captured more cotton rats, whose weights ranged from 70-200 grams (2.5-7.0 oz). Based on these results, the authors believe Havahart live traps are more effective in capturing lighter weight rodents, whereas Sherman live traps are more effective in capturing heavy rodents. However, Havahart traps comprised 85% of the 2,834 traps that malfunctioned (most were sprung, but empty). Sherman live traps could greatly reduce the time required to run trap grids and trap lines (they require less resetting due to malfunctions and collapse, making them easier to move).

REFERENCE

Najera, S.R. 1994. Meadow jumping mice habitat affinities and capture success in two trap types at Bosque del Apache National Wildlife Refuge. Unpublished M.S. thesis. New Mexico State University. Las Cruces, New Mexico. 86 pp.

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Biologists have often had trouble determining the causes for variations in wildlife populations and plant abundance and their interrelationships. In the wild, food chains prevail and transfer nutrients from the sun to plants, from plants to herbivores, and from herbivores to carnivores. A classic ecological chicken or egg question has always been whether plant abundance determines herbivore (and later carnivore) populations, or vice versa. A problem in finding the answer to this question is the difficulty in first finding an intact food chain that has a large predator, like the wolf.

Wildlife ecologist Rolf O. Peterson of the Michigan Technological University at Houghton, Michigan, and a research partner reported in the December 4 issue of Science (as excerpted from Science News) that they may have found an answer. Studying the interrelationships of moose and wolves at Isle Royale National Park for the past 35 years, biologists have learned much about the interactions of predator and prey. Recently, Peterson research team member Brian McLaren began to add vegetation to the analysis.

Specifically, McLaren noticed that balsam fir (a primary food of moose) growth rings narrowed periodically, indicating cycles of low growth that corresponded to high moose numbers. After graphing the suppressed tree growth periods with both wolf and moose population fluctuations, the scientists found an interesting correlation. Tree rings appear to narrow only after wolves decline and moose increase. More importantly, a 1-2 yr time lag occurs between a decline in wolves, an increase in moose, and suppressed growth in the balsam firs. In the early 1980s, Isle Royale wolves declined markedly, probably due to disease. After a few years, the moose population increased and browsed more heavily on the trees. A year or two later, the trees showed signs of stress.

Accordingly, the researchers have ruled out the idea that vegetation availability regulates moose on the island. Rather, they have subscribed to the notion of top-down regulation. Of course, the study requires more data, but Peterson commented that the study illustrates the broad "repercussions of a few top-level carnivores in an ecosystem."

Editor's note: It will be interesting to watch for changes in the Yellowstone aspen groves (commonly browsed by elk) following wolf release there. PS

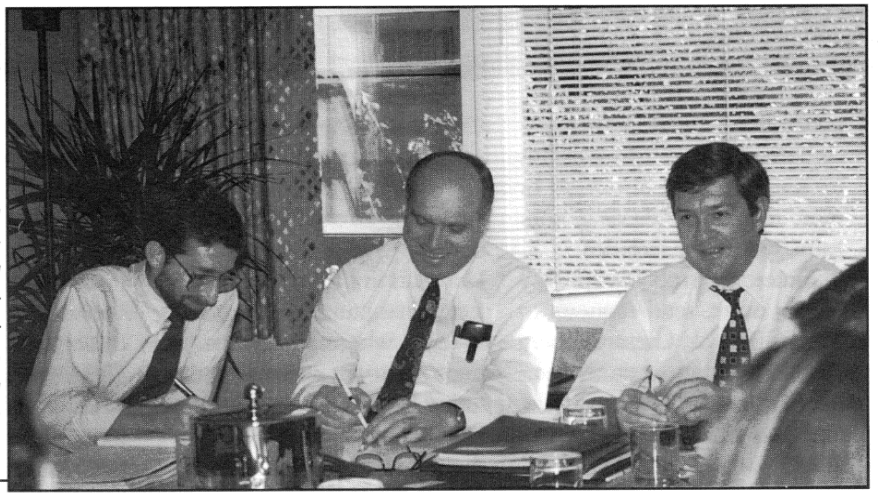

Figure 1. Assistant Secretary for Fish and Wildlife and Parks George Frampton (right), former Acting Associate Director, NPS Natural Resources, Denny Fenn (middle), and Shenandoah Center for Resources Leader Bob Krumenaker at the initial ad hoc working group gathering in October.

Report on the Ad Hoc Task Force on the Future of Natural Resource Management in the National Park Service

By Bob Krumenaker

In recent years, it has seemed as though NPS natural resource management has received lots of rhetorical support but not much else--the establishment of the NBS took away the momentum we had slowly and painstakingly gathered to strengthen our programs, and then restructuring plans appeared ready to sap us further. So when I read the Assistant Secretary George Frampton memo to the Director last fall approving restructuring only if we strengthened natural resources, I eagerly volunteered to be part of the ad hoc group he was forming to make it happen. This appeared to me to be the best--and possibly only--opportunity we would have for a long while to make major changes in the culture of the agency, to (in Frampton's words) make natural resources "flourish."

The ad hoc group convened in Washington last October, with high expectations. Sixteen of us, plus four assistants who became integral participants, attended. Denny Fenn, then Acting Associate Director for Natural Resources, chaired the panel. We came from parks, regions, the Washington Office, and the NBS. We were resource managers, scientists, park managers, planners, and policy people. Director Kennedy and Assistant Secretary Frampton gave us our charge that Monday morning to:

- Redefine natural resource management in the NBS era
- Suggest changes to the restructuring plan as needed to make natural resource management "flourish"
- Define the role of research in a post-NBS, restructured NPS, and suggest enhancements to the NPS-NBS relationship to help assure that our biological research needs are met, and
- Update the 1992 servicewide natural resources strategic plan

Frampton made it clear that he wanted specifics that could be implemented immediately, not a long and bureaucratic report. His enthusiasm and willingness to upset the status quo were infectious, though I think we were nonplussed by the enormity of the changes we were being asked to recommend and the sheer improbability of this opportunity.

Drafting the report required many rewrites before we were satisfied that we had found the right combination of substance, tone, and length to be most effective. Released in late January, this report:

- Articulates guiding principles for an enhanced natural resource management program
- Outlines a core program of natural resource management services
- Enhances the visibility of natural resources at the field director level
- Clarifies the role of the chief scientists in the new organization, and
- Recommends reengineering a number of natural resource management processes

More specifically, the ad hoc report recommends:

- Fully supporting, through the budget process, the Stewardship Today for Parks tomorrow goal to double resource management staff by the year 2000 and fully implementing the approved Inventory and Monitoring Program
- Using incentives to assure that natural resource expertise and considerations are part of major park decisions
- Increasing natural resource support staff for clusters to at least 11 FTEs (full-time equivalent positions) and establishing a research advisor and natural resource management associate director at each field director office
- Strengthening the highly specialized expertise of the National Natural Resource Center (NNRC--presently the Washington Office Natural Resource Divisions in Colorado)
- Accelerating natural resource professionalization in parks
- Preparing managerially skilled resource managers for career advancement
- Creating a national chief scientist position to act as liaison between us and the NBS, USGS, and other agencies who conduct research on our behalf, and coordinate all remaining natural resource research activities conducted internally
- Providing research liaisons to NBS regional offices through field director office research advisors

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Late Triassic Dinosaur Tracks Reinterpreted at Gettysburg National Military Park

By Vincent L. Santucci and Adrian P. Hunt

Long before the footsteps of Union and confederate soldiers traversed south-central Pennsylvania, early dinosaurs left their footprints in ancient mud. Fossilized tracks preserve evidence that dinosaurs existed in the Gettysburg area over 200 million years ago during a time period called the Triassic. The tracks also illustrate another example of a NPS unit, primarily focused on cultural resources, that must face the challenges of managing and interpreting paleontological resources.

The dinosaur tracks are preserved in blocks of mudstone that were quarried from an area outside park boundaries. However, the quarried blocks were transported to the park and used in the construction of stone bridges during the 1930s. In 1937, over 50 additional tracks were discovered in blocks from another nearby quarry within Adams County. The park superintendent at that time was especially interested in the fossils and placed some on display within the park. He encouraged interpretation of the tracks and unofficially coordinated distribution of some specimens to the Smithsonian Institution, Carnegie Museum of Natural History in Pittsburgh, and the State Museum of Pennsylvania in Harrisburg. Today, the tracks are informally monitored by park rangers and are interpreted by rangers and concessioners alike.

Altogether, tracks are known from two localities in Gettysburg Basin, the Trostle Quarry in Adams County, and a smaller quarry near Goldsboro in York County. All were discovered in the Late Triassic Gettysburg Shale, a rock formation that also occurs within the park. These deposits were laid down in a gradually deepening trough of sediments that comprise the Newark Supergroup.

The park files at Gettysburg National Military Park identify these fossil tracks as *Grallator* and *Anchisauripus*. However, these identifications are based upon interpretations recognized in the 1930s. Research into fossil tracks has advanced significantly over the past two decades and we are now able to offer a different interpretation of the Gettysburg tracks. The fossil tracks represent the ichnogenus *Atreipus* which was first described by Olsen and Baird in 1986. The tracks can be further identified to the ichnospecies *A. milfordensis*.

Atreipus milfordensis represents, as of yet, an undescribed dinosaur that exhibits a theropodlike pes (foot) in combination with a short-clawed and functionally tridactyl (three-toed) manus (hand). The track pattern indicates that this dinosaur habitually used all four limbs in locomotion. The manus track is incompatible with any known theropod (carnivorous, upright dinosaurs like Tyranosaurs, that usually have small forelimbs). Theropods have large trenchant manus claws that are designed for grasping, not walking. This pattern of manus and pes tracks is unusual and a condition not exhibited in any other described dinosaur tracks.

The tracks are recognized as dinosaurian because of the birdlike tridactyl pattern of the pes track (fig.1). This pattern, represented in the foot skeleton, is a derived character for dinosaurs. Olsen and Baird (1986) suggest that *Atreipus* may represent the track of a very early ornithischian (bird-hipped) dinosaur.

Late Triassic tracks are also known from Dinosaur National Monument and Petrified Forest National Park (Santucci & Hunt 1993). The Late Triassic was the phase of vertebrate history in which the dinosaurs first originated. Research investigations regarding fossil tracks provide information not available solely through the study of fossil bones and teeth. Tracks and trackways can yield information about behavior, locomotion, and paleoecology. Additionally, as with the Gettysburg fossils, tracks can yield information about animals that are not yet known from skeletal material. The presence of early dinosaur tracks at Gettysburg provides park rangers with the opportunity to interpret the local history well before the fateful days in July 1863. PS

Figure 1. Fossil manus and pes tracks of Atreipus milfordensis *from atop a stone bridge at Gettysburg National Military Park, Pennsylvania.*

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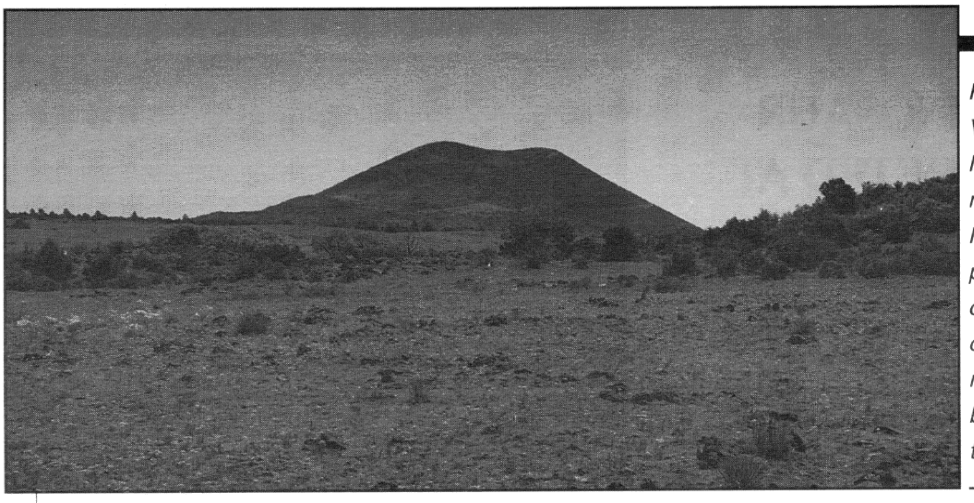

Figure 1. Capulin Volcano National Monument in northeastern New Mexico preserves this classic cinder cone volcano, now thought to be much older than before.

Capulin Volcano is Approximately 59,100 Years Old

Cosmogenic helium aging technique key to clearing up age old question

By William O. Sayre, Michael H. Ort, and David Graham

Capulin Volcano National Monument (fig. 1), located in northeastern New Mexico, preserves a small portion of the Raton-Clayton Volcanic Field. This field contains a surprisingly wide variety of volcanic rock types (Gust 1990). It is the easternmost Cenozoic volcanic field in North America, and is located near the intersection of the Rio Grande Rift and the Jemez Lineament, two zones of crustal weakness. These characteristics make Capulin Volcano an interesting subject for geologic research. Under a cooperative agreement between the park, the NPS Southwest Region, and the College of Santa Fe, we began a geologic research project two years ago. Park staff have been closely involved with the project and Mr. John Morrow and his family have provided access to their ranchlands for mapping lava flows. This report focuses on one facet of the research: the age of the volcano.

Volcanism in the Raton-Clayton Volcanic Field began about 8.2 million years ago and continued until Capulin Volcano erupted (Stormer 1972), the time of interest in our study. Previous attempts at determining the age of Capulin Volcano have focused on its relationship with the nearby Folsom Man site.

Age of the Folsom Man site

Archeologists excavated The Folsom Man site, located about 10 mi (16.1 km) from Capulin Volcano, in 1926. It is famous because the excavators found projectile points in direct association with the remains of an extinct bison (Bison antiquus taylori), indicating that humans were in this region much earlier than had been previously thought (National Park Service 1994). The find is in stream deposits (or alluvia) laid down by the Dry Cimarron River and its tributaries. Haynes et al. (1992) dated a composite sample of five discrete lumps of charcoal from this horizon (the sedimentary layer corresponding to human occupation) using accelerator mass spectrometry, and reported an age of 10,890 ± 50 years before present (B.P.). An earlier carbon 14 (^{14}C) determination on other charcoal yielded a date of 10,000 years B.P. (Muehlberger 1955), and the bison bones revealed a ^{14}C date of 10,260 years B.P. (Anderson and Haynes 1978).

Bryan (1937) was the first to study the geology of the Folsom site, and he identified two alluvial sequences, the lower of which is the Folsom occupation horizon. Charcoal from the upper one, also alluvial in origin, has a ^{14}C date of 4,350 years B.P. (Muehlberger 1955).

Nine miles down the Dry Cimarron from the Folsom site, Muehlberger (1955) identified Capulin Volcano basalt flows sandwiched between what he interpreted as Bryan's two alluvial deposits. Hence, the Capulin eruption was assigned an age range of between 10,000 and 4,350 years B.P. Such correlation of stream deposits is very difficult, however, due to discontinuous outcrops, and the date has never been considered definitive.

Subsequent work showed that this is indeed the case. Anderson and Haynes (1978) identified several distinct alluvial deposits at the Folsom Man site, and they concluded that the basalt flow in the Dry Cimarron Valley overlies an alluvial sequence older than the Folsom occupation horizon. They also made a ^{14}C age determination that confirms this; the age of a baked organic soil from this older unit yields a date of 22,360 ± 1,160 years B.P. That was a minimum age; the actual age could have been older due to contamination of the sample by modern plant materials.

Altogether, these studies indicated that the eruption of Capulin Volcano took place before 22,000 years B.P., and Folsom hunters probably did not observe the eruption. However, these previous studies did not date Capulin Volcano directly.

New age determination

In the most recent study, we determined the age of a sample of Capulin basalt using the cosmogenic helium technique. Cosmogenic helium dates provide information on how long a particular rock sample has been within about 1 m (3.2 ft) of earth's surface (Cerling 1990). Cosmic rays produced by the sun and other stars enter earth's atmosphere and travel through it. Some of the rays are slowed and stopped due to interaction with the atmosphere, but most make it to earth surface. These cosmic rays spall heavier atoms in the rock, splitting them into smaller atoms, especially helium 3 (^{3}He). The cosmic ray flux is relatively constant, and its small variations have been documented in detail. Therefore, the production of ^{3}He, normally a very scarce isotope, occurs at a steady, known rate at earth surface. The ^{3}He:^{4}He ratio, which compares the amount of cosmogenic helium (^{3}He formed by cosmic

ray bombardment) with normal helium (^{4}He, common in the atmosphere and rocks), is then used to determine the amount of time a rock surface has been exposed to the atmosphere. A correction is made for altitude and latitude to account for the effects of the atmosphere on cosmic rays.

Careful sampling is required to date an eruption age. Researchers must first find a lava sample that has been at the surface in its present orientation since cooling. At Capulin Volcano, we sampled a lava flow feature near the volcano's boca, or mouth (fig. 2), that formed when lava was squeezed upward through a crack, creating a thin spine. This feature has remained in this form, with scrape marks on its side, since the lava flow cooled. It also has a large field of lava rubble around it, with no trees or vegetation to shield it from cosmic rays, and it is not in a position for deep snow build up. These circumstances lead us to interpret the cosmogenic helium date as the age of the lava flow sample.

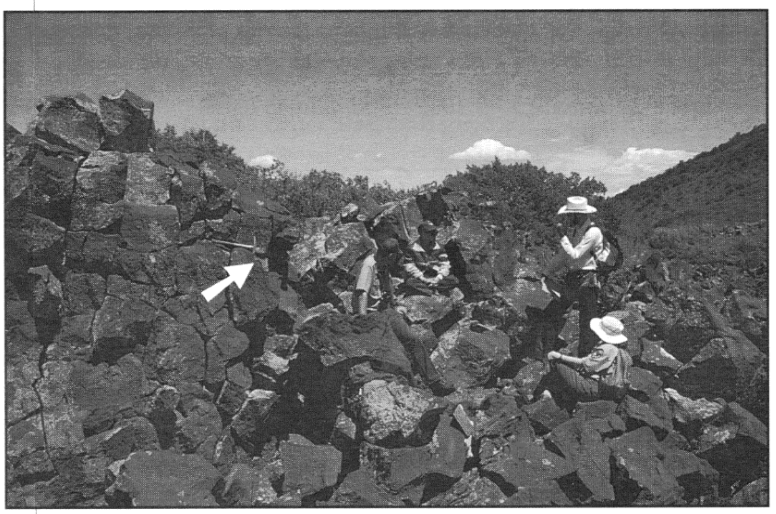

Figure 2. Long ago, during eruption, cinders on Capulin Volcano gave way to lava that opened a vent near its base. Researchers collected a lava sample (below the rock hammer) at this vent or boca for cosmogenic helium dating.

Our results indicate that Capulin Volcano is 59,100 years old ± 6,000 years. Helium dates can be younger than the true age of a volcano. As already mentioned, cosmogenic helium in the rocks results from the amount of time the rocks are exposed to cosmic rays. Any rock shading by vegetation, overlying soils, snow, etc., would reduce the cosmogenic helium level in the rocks and would result in a younger age. However, we carefully chose a sample site that we believe has been exposed to the atmosphere since Capulin erupted. We therefore suggest that Capulin Volcano is late Pleistocene rather than Holocene in age.

Geomorphic analysis

The geomorphology, or shape, of Capulin volcano also indicates that it is not particularly young. Cinder beds at the outer edge of the rim of the volcano dip inwards toward the crater. If a volcano is young and little affected by erosion, we would expect outward dipping layers. As a volcano ages, outward dipping cinder beds on its rim are likely to be removed by erosion, leaving only the inward dipping portions.

A prominent 30-foot-thick spatter flow is located on the southeastern edge of the rim. A spatter flow resembles a normal basalt flow; however, it is formed by the agglomeration of small amounts of lava (spatter) thrown out of a vent and extends for only a short distance. The rim spatter flow is partially unsupported by cinder and juts out approximately 30 ft from the side of the volcano. If the volcano were young, we would expect the flow to be completely surrounded by cinder. In an older volcano, we would expect erosion to carry away some of the cinder, leaving the spatter flow exposed. Similarly, loose cinders form an apron around the volcano, indicating that they have had time to erode from the main cone, even though erosion is slow in this dry climate.

Further studies

The geomorphic observations and new age determination are compelling; however, we need to conduct further analyses to confirm that the volcano is older than previously understood. We plan to make an additional cosmogenic age determination (using aluminum instead of helium) and another researcher will make an argon-argon age determination. We have already carried out paleomagnetic sampling of the basalts, and will study these data. We plan to submit a final report of this project, including the additional age determinations and a discussion of the other elements of the project, for future publication in *Park Science*.

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Pecos National Historical Park Mammal Survey Data Help Solve Hantavirus Mystery

Figure 1. This adult deer mouse (Peromyscus maniculatus), *collected during the biodiversity baseline survey at Pecos, is one of several rodent species that carries hantavirus, an organism that causes severe respiratory collapse in humans. Rodent populations increased 10 times during 1992-93 spreading hantavirus and killing 45 people.*

By Robert R. Parmenter

In the autumn of 1992, the Pecos National Historical Park in northeastern New Mexico began a collaborative wildlife survey with University of New Mexico biologists Dr. Robert R. Parmenter and David C. Lightfoot. The purpose of the baseline survey was to evaluate the vertebrate and invertebrate fauna of the newly acquired Forked Lightning Ranch, which surrounds the existing park. However, with the survey only into its first year, a sudden and unexpected need for the wildlife data emerged.

In the spring of 1993, scientists at the Federal Centers for Disease Control and Prevention (CDC) in Atlanta enlisted the aid of the park project scientists to assist in identifying the ecological relationships of the recent epidemic of Hantavirus Pulmonary Syndrome (HPS) in the southwest. A previously unknown species of hantavirus (family Bunyaviridae) caused the newly identified disease that resulted in 45 deaths.

Hantaviruses comprise the virus group responsible for hemorrhagic fever in Asia and Europe. However, instead of the more typical kidney malfunctions associated with hemorrhagic fever, the new HPS virus (named "Sin Nombre"–Spanish for "without name"–by the CDC) caused rapid and severe respiratory collapse. During 1993, the mortality rate for HPS victims was near 60%. Originally thought to be restricted to the Four-Corners region of New Mexico, Colorado, Arizona, and Utah, the disease has now been documented in 18 states, spanning the continent from the west coast to Florida and New England.

Virologists at CDC identified the virus in June, 1993. The investigating scientists immediately suspected that, as with other Hantaviruses, the likely vector for the disease would be a rodent. Preliminary serological (blood) tests on field-caught rodents from the epidemic region revealed the presence of the virus in several species of deer mice (*Peromyscus* [figures 1 and 2]), wood rats *(Neotoma),* and chipmunks *(Eutamias)* (Childs et al. 1994).

In view of the rodent connection with this disease, medical investigators and public health officials needed ecological information on the deer mouse and other native rodent species. Anecdotal information from residents in the afflicted areas suggested that rodents were exceptionally abundant over the winter of 1992-93, and officials speculated that, if true, the increased potential for rodent-human contact and disease transmission might account for the sudden epidemic.

Biologists with the University of New Mexico and the National Park Service were the only scientists having long-term data on rodent communities in the region. At the request of the CDC and New Mexico Health Department, these researchers provided detailed demographic analyses from 1989-93 for the 22 rodent species inhabiting central and northern New Mexico. The data showed 10-fold population increases in various *Peromyscus* species, wood rats, and chipmunks during 1992 and early 1993. Population increases occurred simultaneously in grasslands, desert-shrublands, and woodlands. Comparisons of the rodent data to regional climatological data indicated that the rodent population dynamics were positively associated with the 1992 El Niño and the above-average precipitation during the winter of 1992-93.

These results provided a possible answer to the question of why the epidemic had occurred when and where it did. With exceptionally high densities of rodents in New Mexico in the spring of 1993, the probability of human-rodent contact was substantially increased, permitting a concomitant increase in disease transmission. Parmenter presented the study findings in mid-July, 1993, at a Hantavirus conference at the CDC Headquarters in Atlanta, and continued follow-up monitoring into 1994.

In addition to addressing the present-day questions on rodent population dynamics, rodent specimens collected during the Pecos project have also contributed to answering another question: Is the HPS Sin Nombre virus a "newly evolved" virus, or has it actually been in the region for years? The University of New Mexico Museum of Southwestern Biology routinely collects rodents for museum specimens from all of its study sites. Under the direction of Dr. Terry L. Yates, Curator of Mammals, field crews collected tissue samples (heart, liver, kidney, spleen, lung, blood) and chromosomes from rodent specimens each year, which were then archived in ultra-cold museum freezers. University of New Mexico biologists are now collaborating

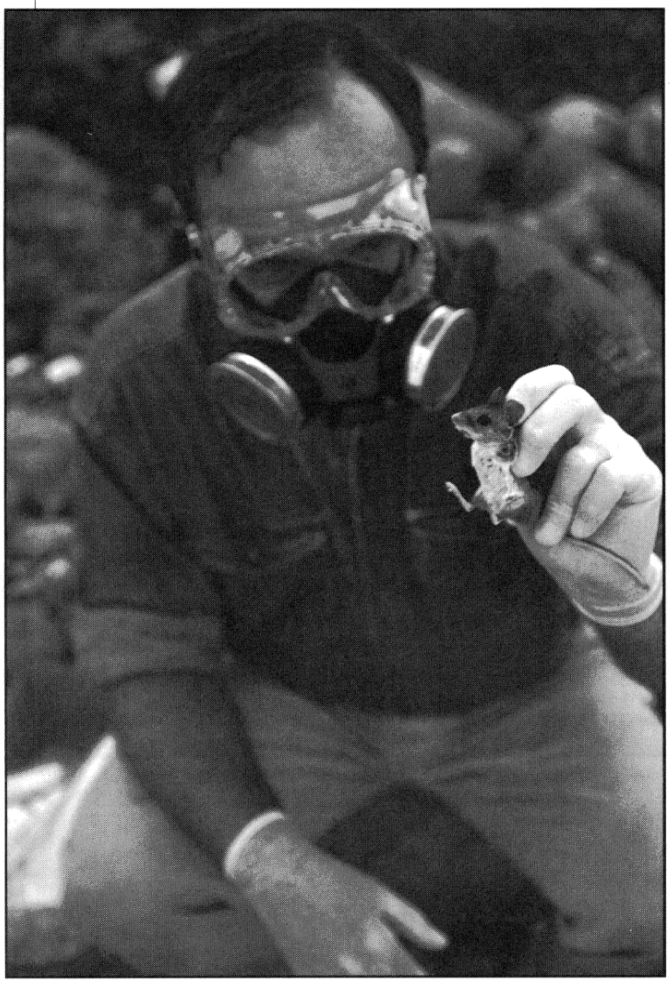

Figure 2. The author holds an adult pinyon mouse (Peromyscus truei) *during mark-recapture studies at the national historical park. The respirator, goggles, and gloves are standard equipment for rodent surveys now!*

with UNM Medical School researchers and CDC scientists in examining the archived rodent tissues to determine if the virus has indeed been present historically, though undetected, in the regional rodent populations, or if additional new viruses are present.

To date, we think that different "species" or strains of the virus infect different rodent genera, and that the phylogenetic relationships among the rodent and virus groups exhibit a high degree of similarity; this indicates a potential coevolutionary history between rodents and hantaviruses in North America (see Hjella et al. l994). Scientists are still analyzing tissue samples taken from the park, along with even older samples from the museum and Texas Tech University. These studies promise to contribute considerably to our understanding of the biology of hantaviruses in nature.

Researchers are also using the results of these analyses to develop rodent-virus sampling strategies and disease prevention plans for human populations. New techniques for dealing with rodents in field studies and human dwellings have been developed in collaboration with CDC scientists (e.g., Mills et al. 1995). They are employing predictive relationships to ascertain the likelihood of a sustained population outbreak for the rodents in New Mexico, and to estimate the effectiveness of possible control measures to reduce human-rodent contact. These predictions, along with continued up-to-date measurements of rodent populations at various New Mexico study sites, will contribute insights and direction to the strategies and contingency plans developed by regional public health officials to battle future HPS epidemics. PS

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coding methods are likely to be different, too. While consensus will be difficult, participants learned several data coding methods that will help improve consistency in future data development projects.

The group also discussed the new national metadata standard adopted by the Federal Geographic Data Committee last summer. The voluminous document that communicates the standard must be applied to all geographic data collected after January 1995. Complying with the standard has created such a large workload that the group discussed ways to reduce this burden. One suggestion was to create a database template that would ease data entry when compared with the typical word processor data entry method.

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John Day Fossil Beds National Monument, Oregon, recently consulted with regional staff about the potential uses of a park GIS. High on the park list of needed GIS applications is paleontological research issues. A GIS could be used to maintain vertical and horizontal fossil location data and fossil locality and stratigraphic information. The system could also be used to track fossil prospecting events, which will help ensure that collections are not skewed to only known locations in the park. Other important resource-related uses for the system will be vegetation and fire management and integrated pest management. The park will principally use ArcView 2 software, although they plan to use PC ArcInfo for more complicated vector-based analyses.

Alaska Region

Several new regional publications are available:

Demma N.J., B.W. Dale, L.G. Adams, and K.B. Fox. 1994. Ecology and Demography of a density low wolf population in Yukon-Charley Rivers. NPS/AR/TR 94/21.

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Swanson, D.K. 1995. Landscape Ecosystems of the Kobuk Preserve Unit, Gates of the Arctic National Park, Alaska. NPS/ARRNR/NRTR-95/22.

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Do Wetlands Regulations Help Protect Park Resources?

Figure 1. Construction of this drainage ditch in a housing development bordering Gulf Islands National Seashore was halted using provisions in Section 404 of the Clean Water Act. Water Resources Division and park staff showed that this ditch would have drained a valuable park pine savannah wetland (right).

By Joel Wagner

National Park Service employees may have mixed feelings about federal wetlands regulations. At times, the regulations implementing Section 404 of the Clean Water Act and the NPS guidelines implementing Executive Order 11990 (Protection of Wetlands) seem unnecessarily convoluted--just more hurdles that slow progress on needed NPS construction and maintenance projects. At other times, these are the tools of choice for protecting park resources from destruction. So I pose the question: Do wetlands regulations facilitate or hinder the NPS mission?

Section 404 as a resource protection tool

Section 404 of the Clean Water Act includes a permit requirement for discharging dredged or fill material into "waters of the United States," including wetlands. Commonly known regulated activities include construction of building pads or road beds in aquatic habitats, but a court has recently ruled that mechanized land clearing and excavation activities are also regulated. The law applies to federal agencies, so we must comply with the same permit procedures required of private builders.

In evaluating the adverse impacts of a proposed activity during the permit review process, the U.S. Army Corps of Engineers (COE) must consider both on-site impacts (i.e., the amount and type of habitat directly displaced by fill) and off-site impacts (e.g., effects of drainage facilities on adjacent property or changes in downstream water quantity or quality). This latter aspect, consideration of off-site impacts, opens the door to NPS input and involvement in COE decisions on permits for projects that, although not on NPS property, may adversely impact NPS resources.

A proposed housing development bordering the Davis Bayou Unit of Gulf Islands National Seashore, Mississippi, provides a recent illustration of how the 404 permit process can be used as a tool for protecting park resources. In this case, the subdivision design submitted to the Corps called for a stormwater detention and drainage ditch immediately outside the park boundary (fig. 1). Unfortunately, the Corps did not contact the park regarding this proposal, and permitted the developer to proceed with construction during 1994 under the presumption that there would be no unacceptable impacts on NPS resources. The park first learned of the project after observing ditch construction and landclearing along the park boundary. After consulting with the NPS Water Resources Division regarding 404 regulatory procedures and effects of the project on the hydrology of pine savannah wetlands at Gulf Islands, the park convinced the Corps to issue a stop work order pending evaluation of impacts on this valuable wetland ecosystem.

The halt created some breathing room, during which we conducted groundwater drawdown analyses, provided additional policy-regulatory support to the park, and installed a network of observation wells to evaluate effects of the proposed development on pine savannah wetland hydrology (fig. 2). The Water Resources Division also is funding a park-proposed study to analyze vegetation, soil, ground water hydrology, endangered species, and water quality components of this wetland ecosystem. Both the park and the Water Resources Division believe that through the 404 permit process, we can negotiate an alternative plan with the developer that assures that park resources will not be degraded.

A word to the wise: contact the appropriate COE regulatory office to ensure that they will notify the superintendent whenever a regulated activity is proposed in the vicinity of your park.

NPS wetland guidance in park facilities planning

Executive Order 11990 is the basis for most NPS wetlands policy. The order recognizes the loss of over 50% of national wetland resources, and directs each federal agency to develop procedures to "minimize the destruction, loss, or degradation of wetlands, and to preserve . . . the natural and beneficial values of wetlands in carrying out the agency's responsibilities." In response, the National Park Service developed the NPS Floodplain Management and Wetlands Protection Guidelines (45 Federal Register 35916). These guidelines direct NPS managers to avoid actions with the

Figure 2. This Gulf Islands pine savannah wetland was recently spared impacts from adjoining development outside the park.

potential for adversely impacting wetlands when there is a practicable alternative, and to preserve, enhance, and minimize degradation of wetlands when no such alternatives exist. If a project will adversely impact wetlands, staff must attach a statement of findings to either the finding of no significant impact or final environmental impact statement. The brief statement explains the reason for no practicable alternatives to the proposed action and outlines mitigating measures to compensate for wetland loss.

The wetlands guidelines acknowledge that our agency mission is both to provide for enjoyment of the resources and to protect them in perpetuity. That is, they do not say that we absolutely must not impact wetlands in the course of constructing visitor facilities or that we absolutely must restore all wetlands that have been impacted in the past. Rather, they facilitate a balance in the mission with respect to wetland resources, requiring only that NPS project planners seek locations and designs that avoid or minimize wetland impacts, while still meeting project objectives. The guidelines also provide managers with guiding principles when considering external proposals for activities or facilities in NPS units.

Easing compliance

One important step in streamlining NPS wetlands compliance occurred in 1994. In response to reports of delays in obtaining required approval signatures for wetlands statements of findings, the director delegated signature authority to regional directors, with Water Resources Division concurrence. Early indications are that this change has eased the compliance process.

Another way to minimize compliance workload is to gather wetland data early in the park planning process. National Wetland Inventory maps, while not of sufficient scale and accuracy for final compliance purposes, are useful as a first step in eliminating undesirable development sites from consideration. Subsequent steps may include wetland reconnaissance by a knowledgeable NPS employee or obtaining services of a professional wetland delineation contractor. Experience shows that it is far easier to avoid wetlands impacts (and the need for subsequent compliance steps) when adequate data are available as alternatives are being developed.

Section 404 of the Clean Water Act clearly facilitates NPS resource protection as illustrated by the Gulf Islands case. For NPS-proposed facilities with potential impacts on wetlands, internal wetlands guidance also facilitates our mission by helping to strike a balance between visitor use and resource protection. The National Park Service has taken steps recently to streamline our internal compliance procedures, and the Water Resources Division will continue to look for opportunities to make the process more efficient. PS

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- Developing a budget initiative to establish NBS field stations within all NPS areas with significant natural resources, and
- Developing methods to ensure that NPS research needs are served by the NBS

By the time our February 15 briefing of the assistant secretary rolled around, the restructuring effort had made it clear that our recommendations would be considered only in light of mandated FTE reductions. Furthermore, we were asked to recommend actions that could be taken now whether or not the natural resource program can flourish. Despite these limitations, the briefing went well, and both the assistant secretary and director agreed in principle with the findings and recommendations of the report. Both also indicated that they want to do something positive for our programs in response.

The ad hoc working group deliberations, the resulting report, and the recent briefing represent a positive step forward for NPS natural resource management in the restructuring effort. Still, we are not sure exactly what will result. A number of additional steps (including March national leadership council consideration of field director offices, system support offices, the National Natural Resource Center, and other central office staffing) must be taken before we will know the ultimate outcome of the ad hoc working group's recommendations. As stated by the assistant secretary, the issue has now been "crystallized" and discussions on this matter are "to be continued." PS

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Ferrets continued from front page

proximate cause of decline is habitat loss due to prairie dog control programs, diseases, and land use changes over the past century. Biologists estimate that prairie dog distribution today is less than 5% of its historic levels. During the early 1970s, attempts at captive breeding with animals from the dwindling South Dakota population failed and the last captive animal from that population died in 1979. As such, biologists considered the black-footed ferret extinct until 1981 when another population was discovered near Meeteetse, Wyoming. Following outbreaks of sylvatic plague and canine distemper in 1985-86, biologists removed the final remaining 18 individuals from the wild to attempt another captive breeding program.

The U.S. Fish and Wildlife Service 1988 *National Black-Footed Ferret Recovery Plan* adopted goals to increase the captive breeding population to 240 breeding adults and to establish a prebreeding population of 1,500 free-ranging adults in 10 or more populations with no fewer than 30 breeding adults in any population. The plan also encouraged the widest possible distribution for reintroduced populations. Subsequently, an intensely successful breeding program at seven facilities in the United States and Canada increased the captive population in excess of 240, the number expected to retain 80% of the genetic diversity of the founders for 200 years. From 1991-93, biologists released 187 ferrets under a nonessential experimental population designation in Shirley Basin, Wyoming. This designation provides flexibility by allowing biological manipulation of the population for recovery purposes.

In 1994, the National Park Service, U.S. Forest Service, and U.S. Fish and Wildlife Service suggested reintroducing the ferret into the Conata Basin-Badlands prairie dog complex of southwestern South Dakota in an interagency environmental impact statement. The Fish and Wildlife Service published a final rule on August 18, 1994, designating a nonessential experimental population area. Subsequently, each agency signed a separate record of decision to implement the preferred alternative to reintroduce black-footed ferrets in Badlands National Park in the fall of 1994. Our goal for South Dakota is to reintroduce 40 black-footed ferrets each year for 5 years beginning in 1994.

Reintroduction

Site Selection and Preparation

During spring 1994, we selected three black-tailed prairie dog colonies (415 park hectares or 1,025 acres), also known as towns, as locales for fall ferret release (fig. 2). Altogether, approximately 3,726 ha (hectares, or 9,200 acres) of suitable prairie dog colonies exist in or adjacent to the park and lie within the prescribed 17,010 ha (42,000 acre) reintroduction area. We chose the release towns based on habitat quality, juxtaposition within the overall complex, remoteness from visitors, and field crew accessibility. A subtle complication was the reintroduction site location within the Badlands Wilderness Area where mechanical transport is prohibited and approximately 550 bison range freely!

We stratified release sites across the three colonies based on topography, level of prairie dog activity, and potential impact to cultural resources. We used a helicopter to airlift over 4 tons of supplies used in constructing 28 release cages-bison exclosures several months before the ferrets arrived. From June through August 1994, we were busy live-trapping and quarantining, for a 10-day minimum, 675 black-tailed prairie dogs. Following veterinary inspection, we sent prairie dogs to captive breeding facilities to give ferrets an opportunity to imprint on (become familiar with) them. In the park, we posted advisory signs telling visitors of the impending reintroduction activities.

Ferret Allocation

Project biologists recommended that a minimum of 20 male and 20 female juveniles be released initially, based on known ferret survivorship data from Wyoming and South Dakota. In July 1994, the Fish and Wildlife Service allocated 38 juveniles and four adults with unknown sex ratios and we subsequently received 32 juveniles (20 male:12 female) and four three-year-old adults (2 male:2 female). Of these, 17 were imprinted on live prairie dogs and burrow systems at Sybille Wildlife Conservation and Education Center and 19 were unfamiliar (naive) with prairie dogs, having been cage-reared at Metro Toronto, Phoenix, and Henry Doorly Zoos. Project biologists worked with NBS scientists and veterinarians at the two zoos and the education center to fit radiotelemetry

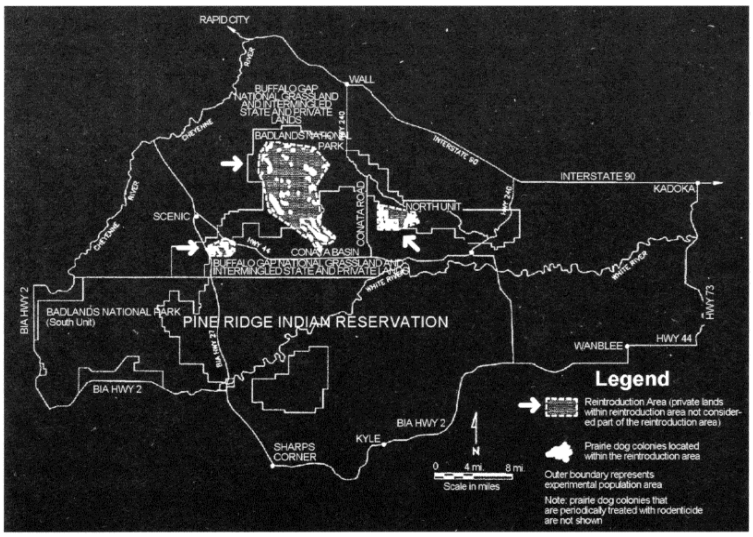

Figure 2. Black-footed ferret reintroduction sites within Badlands National Park, South Dakota.

Figure 3. With in position arou kept warm by a in a surgical te ferrets were ou arrival at the pa

rs just large enough to hold a radio collar d its neck, a briefly anesthetized ferret, blanket, gets a custom fit from park staff at a Badlands reintroduction site. Other tted with collars at zoos before their k.

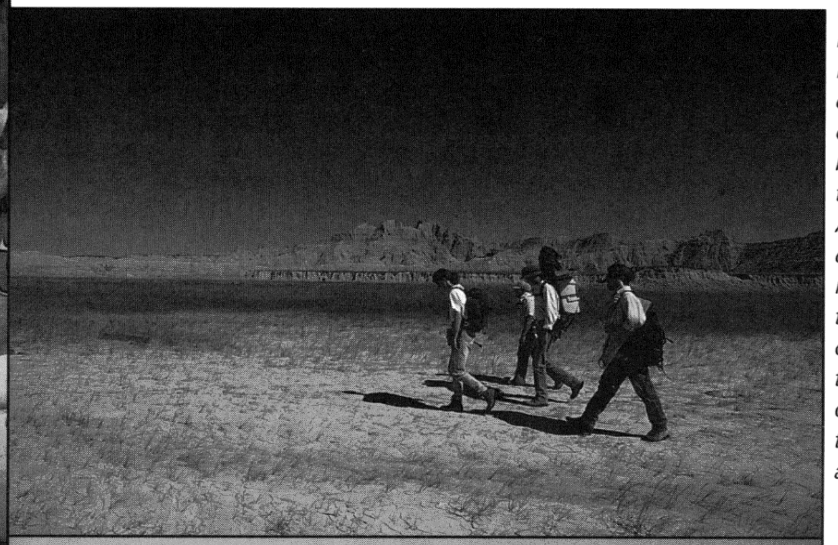

Figure 4. Reintroduction staff, carrying ferrets and other supplies, begin a 3-mile hike to the release sites. A minor complication of the reintroduction was the prohibited use of mechanical transport means in delivering materials to the wilderness area release site.

Figure 5. Inside a bison exclosure, staff prepare a typical nest box, including food tube and underground vault (not shown), for black-footed ferret habitation. Corrugated tubing simulated prairie dog burrows and connected the underground vault to the cage above.

collars on 16 ferrets (fig. 3). Upon arrival at the park, staff backpacked ferrets directly to their preselected release cages (fig. 4). The park encouraged local media to cover the arrival of the ferrets.

Ferret Husbandry

The captive-bred ferrets used in the reintroduction came from two different backgrounds relative to their familiarity with prairie dogs, and this necessitated that we use two different release strategies accordingly. We held the naive animals in release cages for a minimum of 10 days with a minimum 5-day post release cage-attending period (soft release) to permit them to return to the cages for provided meals. We held preconditioned or imprinted animals in a release cage for a maximum of 48 hours with no post-release cage attending (semihard release). All cages included a single nest box (aboveground), food tube, water bowl, and double-sided nest box located in an underground vault and connected to the aboveground cage by 4-in diameter corrugated plastic tubing (fig. 5). Staff examined the ferrets, attended the cages, and collected data on food consumption, ferret and radio collar condition, vault and ground temperature, and weather (temperature, precipitation, air pressure, wind speed). We fed the ferrets approximately 150 g (grams, or 0.4 lb) of black-tailed prairie dog daily.

Cage attendants released the ferrets near sunset by placing a length of 4-in diameter plastic tubing between the cage and nearest active prairie dog burrow (fig. 1, page 1). Although they immediately left the site, attendants reported seeing two ferrets exit the release tube and go directly down a burrow.

Monitoring

Late-summer and early-fall ground temperatures in the Conata Basin-Badlands were hot, reaching over 100° F and averaging 90° F during September. Belowground vaults averaged 75° F during September afternoons and greatly improved conditions for the ferrets during the prerelease phase. In October, the underground vault and aboveground nest box temperatures dropped to a 52° F average.

Badlands National Park operated nighttime aerial telemetric missions along with NBS assistance in telemetry use, training, and study design. Altogether,

Continued on page 18

staff conducted six missions, 3-5 hours each, in parallel with ground telemetry over a 21-day period following release. We detected a total of 62 individual locations, 97% of which occurred within the three release colonies. A majority of telemetric locations (70%) were collected during the first week following release. We noticed that animals moved freely among the three release colonies, but believed their movements within the first 3 weeks after release to be limited to less than 8 km (5 mi). During this time, one radio-collared animal dispersed approximately 8 km (5 mi) and then shed its collar. We also retrieved two other radio collars, but detected no mortalities.

Figure 6. A ferret pokes its head out of a prairie dog burrow at night several days after release and is briefly caught in the light of a researcher trying to assess reintroduction success. Nighttime spotlighting and snowtracking techniques indicate that, although not high, ferret survival is above project goals.

Project staff and volunteers conducted spotlight ground surveys on 21 colonies or focal areas within the reintroduction area (including snowtracking in outlying colonies) over 11 nights from November 28-December 10 (fig. 6). We detected eight ferrets by spotlighting, representing a minimum 22% survivorship 26 days after the last ferret was released; although low, this percentage exceeds the 30-day postrelease survivorship goal of 20%. Before release, we had implanted very tiny transponders (equipped with unique numeric codes) subcutaneously in each ferret to facilitate subsequent identification. After trapping seven of the eight animals and weighing them, we electromagnetically *scanned* each transponder to identity each ferret. Postrelease survival for the identified ferrets ranged from 21 to 82 days, with 71% being preconditioned. Movements of five animals were limited to the three release colonies, while the three other animals moved up to 8 km (5 mi) into adjacent active prairie dog colonies. Subsequently, snowtracking efforts detected several ferrets.

Summary

Recovering the black-footed ferret to a point of delisting is a daunting task. Reintroduction requires maintenance of partnerships and a large contribution of time and resources. At the regional scale, the probability for recovery is a function of available habitat, and habitat lost during the last century is not likely to be recovered. Since 1900, the historic range of the prairie dog has been reduced by approximately 95%, due to disease, agricultural practices, and urban development. Compared with 1870, prairie dogs now occupy only 2% of their historic range (Anderson et al. 1986, *in* Great Basin Naturalist). If the prairie dog ecosystem of the Great Plains is further eroded and fragmented, ferret recovery will become more desperate.

While reintroduction efforts like this help tremendously to recover the ferret, a basic question still remains. Can the black-footed ferret persist in the wild today and in the future under regional land use practices that rendered it nearly extinct? Hope for its recovery lies in the continuation of a strong, but flexible, Endangered Species Act and a prevailing commitment to the conservation of regional prairie dog ecosystems.

Epilogue

Ferret reintroductions continue this year in South Dakota, Wyoming, and Montana. However, the U.S. Fish and Wildlife Service recently released budget priorities for fiscal year 1996 and beyond that jeopardize the captive ferret population, the future availability of reintroduction animals, and the national recovery program. PS

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Dr. Glenn E. Plumb, former Assistant Director of the NPS-University of Wyoming Research Center (CPSU), is a Badlands National Park Wildlife Biologist. Bruce Bessken, winner of a 1994 regional natural resource management award for his role in facilitating the ferret reintroduction process at the park, is Chief of Resource Management at Badlands. Paul Marinari, Biotechnician, served as field coordinator-data manager during the project and has been involved with ferret management since 1989. Contact them at Badlands National Park, P.O. Box 6, Interior, SD 57750-0006, (605) 279-2464. Final results of this study will be presented in an April report.

Developing Natural Resource Bibliographies: A Servicewide Project

By R. Gerald Wright and Marilyn Ostergren

Resource managers have long recognized the need for organized park-specific information in annotated bibliographic databases as a precursor to sound park management and planning. However, efforts to initiate such products over the years, have, with the exception of a few parks, largely been unsuccessful. This failure has primarily been because of limits on the time and money allocated for such activities, personnel transfers between areas in the park system, which disrupts the continuity of efforts, and the lack of an automated technology to support such products. In 1984, Gerry Wright at the University of Idaho CPSU developed a plan for a resource bibliographic database project in the Pacific Northwest Region. This project proposed using "mini-computers" and commercial database software, technologies which were then available at universities and were slowly being introduced into the parks. The Natural Resources Preservation Program eventually funded this project in 1987.

I hired individuals to travel to each of the parks, computers in hand, and scour the libraries, vertical files, local agency files, and any other information sources suggested by the park staff or identified in their surveys in an effort to find items that would be of interest to researchers, managers, and interpreters in the park under study. Project staff entered citation information and associated data along with a few sentences to explain what information was found in the document (particularly important when documents are untitled or contain information not alluded to by the title) and described where the document was held. The project went through several iterations before project managers and park advisors agreed upon the level of detail for each citation. This took anywhere from a few weeks to several months for the work to be completed at a given unit. Using the dBASE database management software, we completed this first round work in 1991.

In 1992, the National Park Service initiated its comprehensive Inventory and Monitoring (I&M) Program and published the *Natural Resources Inventory and Monitoring Guideline (NPS-75)*. At the same time, the National Park Service adopted the Pro-Cite bibliographic software as the servicewide standard for resource bibliographies. As a start, the I&M Program funded a pilot project to convert the existing Pacific Northwest park bibliographies to Pro-Cite, install the software on park computers, and provide training on its use. Now the combined Pacific Northwest 16-park database contains almost 9,000 records.

Pro-Cite proved to be a very suitable medium for park resource databases. It is flexible and able to accommodate the wide variety of information typically found in park files. It is menu driven, relatively easy to use, and meshes well with word-processing software like WordPerfect.

Beginning in 1994, the I&M Program, under the direction of its 10-year strategic plan, began to provide funding to selected regional offices for completing natural resource bibliography projects in their selected parks. These projects are to use the format and specifications developed by the Pacific Northwest Region. The goal of the 10-year program is to compile a basic set of resource data for the approximately 250 park units that contain significant natural resources.

Inventory and Monitoring Program staff selected three regions for funding in 1994: Alaska, Rocky Mountain, and Southwest. Projects in several parks in all of these regions have been completed or are now underway. The Alaska Interagency Resource Library is directing the Alaska Region project, the Center for Colorado Plateau Studies at Northern Arizona University in Flagstaff and the Natural Resource Ecology Lab at Colorado State University in Fort Collins are codirecting the Rocky Mountain Region project, and the CPSU at the University of Idaho is directing the Southwest Region project. Funding for all the remaining regions will begin in 1995.

The ultimate goal of the project is to make park-specific information accessible to those who need it. Resource managers and researchers will be able to sit down at a computer and quickly pull up a list of books, maps, journal articles, unpublished reports, and even memos related to a given subject along with a brief description of each document and where that document can be found. Equally as important, the bibliographic database provides a framework for keeping park resource information organized and up-to-date obviating the need for projects like this in the future. The program has been integrally tied to the efforts of–and relied upon the support of–park-, regional-, and Washington-based NPS librarians, and it will rely on their expertise to assure that the databases are maintained in the future.

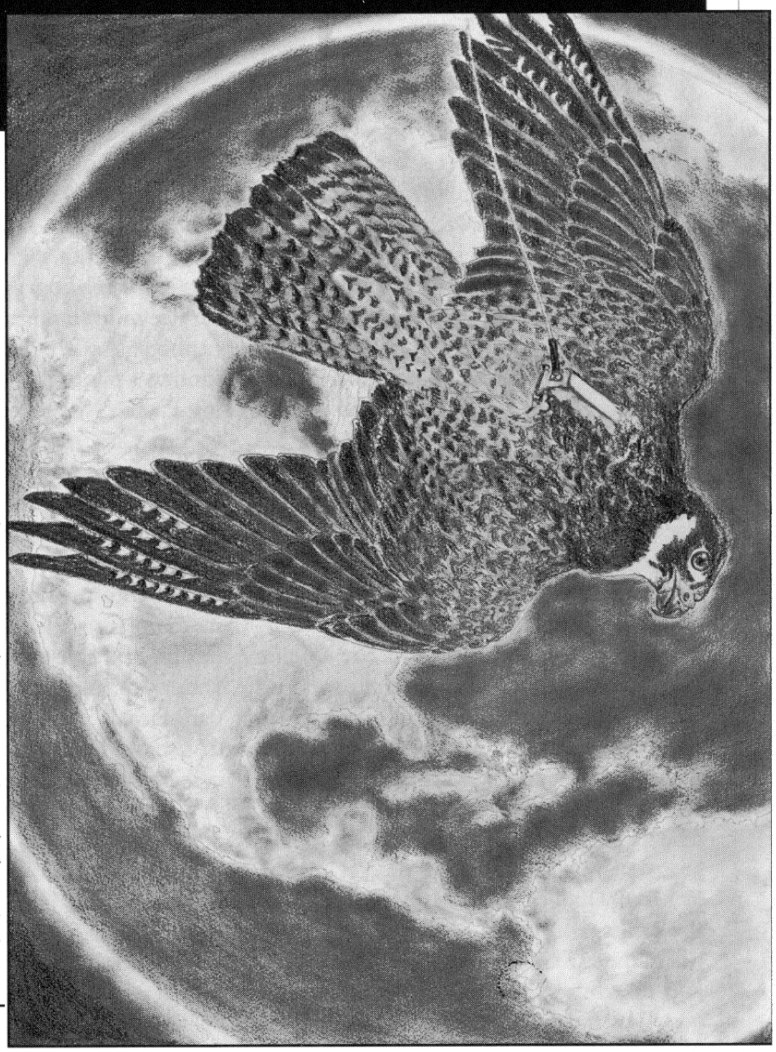
We have been excited to see the original goals set for the Pacific Northwest Region (idealistic at the outset) become, after more than a decade, a reality in a growing number of parks. Plans are now underway at the University of Idaho CPSU to convert the Pacific Northwest, Southwest Region databases, and possibly others to CD-ROM format. One day, in the not so distant future, if all goes as planned, a servicewide resource bibliography should be available on CD-Rom. Actions are also underway to convert other NPS databases, such as the cultural resource bibliography, to Pro-Cite, making them compatible with the natural resource bibliography.

For further information on this program, contact Larry Pointer, the NPS natural resource bibliography coordinator, at (303) 225-3541. PS

R. Gerald Wright is the National Biological Service Unit Leader for the Cooperative Park Studies Unit at the University of Idaho Department of Wildlife Resources in Moscow. Marilyn Ostergren is Research Associate there, and they can be reached by calling (208) 885-7990.

Satellite Radiotelemetry and Bird Studies in National Parks and Preserves

New data-gathering technique provides alternative for studies of wide-ranging wildlife



NPS ILLUSTRATION BY PHILIP THYS

Figure 1. Small, lightweight, and sophisticated, radio transmitters now communicate with orbiting satellites to relay locations of wide-ranging wildlife species to researchers in their offices. Using this technology, scientists recently learned that Alaskan peregrine falcons winter as far away as Argentina.

By Michael W. Britten, Carol L. McIntyre, and Mary Kralovec

Radiotelemetry has revolutionized wildlife study allowing researchers to identify and locate individual animals remotely. Wildlife scientists have used telemetry for many purposes, including estimating population size and demographic parameters, identifying habitat use, and documenting daily activities and migration and dispersal patterns.

Until recently, most telemetric studies relied on very high frequency (VHF) radios and required ground or aircraft tracking. This conventional radiotelemetric technique is only possible when the transmitter and receiver are close together, usually within about 30 km (19 mi), and nothing, such as a topographic feature, obstructs signal transmission. For animals that move long distances or inhabit remote areas, the high cost of locating radio-tagged individuals limits sample size and, consequently, research results. In these cases, a relatively new research tool, satellite radiotelemetry, may be more appropriate.

Satellite radiotelemetry for tracking wildlife

Satellite radiotelemetry tracking uses special transmitters or platform transmitter terminals (PTTs) worn by wildlife (fig. 1) and receivers on board polar orbiting satellites. The PTTs are located using the Doppler effect, a shift in the frequency of radio waves caused by changes in the relative velocity of the transmitter and receiver as the satellite orbits the earth.

This technique is a cooperative effort between the user, the National Oceanographic and Atmospheric Administration (NOAA), and Service Argos, Inc. Argos, established in a 1978 agreement between NOAA, the National Aeronautics and Space Administration, and the French Space Agency, is a global satellite-based location and data collection system dedicated to environmental applications. Argos receives, processes, and transfers data to the user via electronic mail (including NPS CC:Mail), telephone modem, and fax.

How satellite telemetry works

All PTTs transmit a unique code within their 401.65 MHz signal. As the orbiting satellite "rises" and comes into "view" of a PTT, the satellite picks up the signal and identifies the transmitter. The Doppler effect increases the received frequency as the satellite approaches. Once the satellite is directly overhead, its velocity relative to the transmitter is zero and the Doppler effect is absent. As the satellite moves away from the PTT, the frequency shifts lower. Argos determines the PTT location by solving the simple relationship between the Doppler effect and the angle between the PTT and the satellite several times during one satellite pass.

Location accuracy depends on several factors including oscillator (frequency generator) stability, accuracy of the estimated satellite location in space, PTT elevation, and satellite pass duration. Argos classifies the data as class one, two, or three corre-

sponding to locations within 1,000, 350, or 150 m (1,094, 383, and 164 yd, respectively) of true location. Accuracy suffers whenever assumptions used to determine the transmitter location (e.g., that the carrier frequency is really 401.65 MHz) are violated. In wildlife satellite telemetry the transmitters are small and batteries are weak resulting in poor signal quality and inaccurate locations. For many locations, Argos gives no estimate of accuracy; however, all wildlife locations are classified indicating reasons for the inaccuracies. Fancy et al. (1988) assessed the accuracy of satellite-determined locations for PTTs at known locations (some attached to captive animals) and found a mean error of 829 m (907 yd) and a maximum error of 8.8 km (5.5 mi). In their assessment, 90% of the reported locations were within 1.7 km (1 mi) of the true location. Clark (1988) measured location accuracy of PTTs in Wyoming and Montana and found one standard deviation of 541-645 m (592-705 yd, respectively).

Past uses of satellite radiotelemetry

The Argos system has been most heavily used by oceanographers, meteorologists, and hydrologists for applications such as tracking both water and wind currents and oil spills and relaying hydrologic data from remote watersheds. The first successful applications in wildlife research involved heavy, bulky instruments designed for tracking oceanographic buoys and weather balloons (Fancy et al. 1988). An 11.3 kg (25 lb) satellite radio collar was used to track an adult female elk *(Cervus canadensis)* for 29 days in Wyoming in April 1970 (Craighead et al. 1972). Craighead et al. (1971) monitored temperature and light intensity in the winter den of a black bear *(Ursus americanus)* with a satellite transmitter (powered by automobile batteries) placed outside the den. In March 1977, Lentfer and DeMaster (1982) used 5.6 kg (12.3 lb) transmitters to track polar bears *(Ursus maritimus)* by satellite.

Early PTTs were too heavy for tracking birds. Gradually lighter and smaller PTTs were developed and used to track larger birds such as bald and golden eagles (*Haliaeetus leucocephalus* and *Aquila chrysaetos*) (James D. Fraser. 1994. Virginia Polytechnic and State University. Blacksburg, Virginia. Personal communication), swans (*Cygnus columbianus*) (Higuchi 1991), cranes (*Grus vipio and G. monacha*) (Higuchi 1992), storks (*Ciconia ciconia*) (Berthold 1992), and albatrosses (*Diomedea exulans*) (Weimerskirch 1993).

Scientists have also studied marine species using satellite telemetry, including loggerhead sea turtles (*Caretta caretta*), dolphins (*Stenella attenuata*), and basking sharks (*Cetorhinus maximus*) (Fancy et al. 1988). Unfortunately, both conventional and satellite telemetry are limited for marine animal studies because water rapidly attenuates radio signals. Some researchers have attached satellite transmitters to floats trailing behind and above the study animal to solve this problem.

Limitations

Satellite radiotelemetry is not currently appropriate when the scale of the movements being studied is small (e.g., habitat use or home range size). The smallest satellite transmitters currently available weigh between 25-30 g (0.9-1.1 oz), limiting their use for small birds (less than 1,000 g or 35 oz) or other small animals. Data can be delayed 20 minutes to 3 hours before being processed by Argos and relayed to the user. Because the satellites are in polar orbit, there are more frequent data collection periods near the poles than near the equator. For example, at 65° north latitude (approximately the latitude of our peregrine falcon studies) the satellite passed overhead an average of 22 times each day, whereas at 30° north the average dropped to nine overpasses per 24 hour period, and at the equator only seven per day. Finally, PTTs cannot be located by researchers using conventional telemetry, making removal and recovery of transmitters difficult. Battery power also limits the use of small transmitters; however, the PTTs can be programmed to transmit at specified target intervals to extend battery life. For example, for the peregrine falcon study, we programmed the PTTs to transmit 8 hours every other day during fall migration and 8 hours every 2 weeks during winter to conserve the expected 500 hours of battery life.

Costs

Satellite telemetry is expensive, with each transmitter costing between $1,800-$3,500 (the PTTs used in our studies cost $2,700 each). We paid Argos approximately $1,000 per PTT for 500 hours of data transmission . By comparison, conventional telemetry is also costly. VHF transmitters cost $150-$350 each, and a receiving system (receiver, antennae, and optional scanner) costs $750-$3,500. Ground tracking requires at least one observer or automated tracking stations, and associated costs. Costs increase dramatically as the study area increases. If large, aerial tracking and associated aircraft, pilot, and fuel costs, becomes necessary. Aerial tracking is also risky for the observer and pilot, as reported in the last issue of *Park Science,* and is a cost that should always be considered. Furthermore, studies of highly mobile species require scientists to mark and track more animals, due to emigration.

Sometimes, satellite telemetry is a cheaper research alternative. No ground observer, tracking vehicle, receiver, aircraft, or pilot is required. Data entry costs nothing and produces no transcription errors (data are received in ASCII text files). Unlike conventional telemetry, satellite radiotracking costs do not increase with the size of the study area and the chances of "losing" animals that leave the tracking area are minimal. Kralovec (1994) found that the cost of locating one bald eagle per day in southeast Alaska was lower using satellite telemetry ($19.39 per location) than conventional telemetry ($33.32 per location).

...Only satellite telemetry provides a means to document entire migratory routes–from Alaska to Argentina and all points in between

Continued on page 22

Compared to mark-recapture techniques, satellite telemetry is more efficient. In bird banding studies, for example, recapture rates are very low, often less than 1%, requiring that many animals be marked to achieve adequate sample size. Using satellite telemetry, barring transmitter and harness difficulties, all marked animals can be remotely located and identified. For example, in our study of the migration routes of adult female peregrine falcons, we successfully tracked 11 of 15 marked birds during fall migration and nine of the 15 to their wintering sites. In three cases the birds appeared to have removed the transmitters.

Satellite telemetry is not subject to the same bias as mark-recapture and conventional telemetry methods; once an animal is marked a researcher can relocate it almost anywhere. Researchers have little difficulty discriminating between mortality and emigration.

Tracking birds using satellite telemetry

Juvenile golden eagles in Denali National Park, Alaska

In 1987, the National Park Service began a study of the nesting ecology of golden eagles in Denali National Park, Alaska. One objective was to determine the migratory routes and wintering areas of juvenile birds. Toward this end, we banded juvenile eagles and tagged three nearly fledged golden eagles (one in 1990 and two in 1992) with 90 g (3.2 oz) PTTs using a backpack-style harness. We successfully determined the autumn migration routes and wintering area for two of the young eagles.

In 1990, the first study eagle left the park on September 23 and moved along the northern edge of the Alaska Range until it turned south near Whitehorse, Yukon Territory, Canada. From October 1-17, the bird continued south through interior British Columbia and into east-central Idaho. Between September 23 and October 17, it moved 2,530 km (1,569 mi) from its Denali nest (an average of 97.5 km or 60 mi per day). The eagle remained in east-central Idaho on the western side of the Bitterroot Mountains from October 17, 1990, through February 18, 1991, the last transmission date.

In 1992, a second study eagle left the park on September 27 following nearly the same route as the 1990 bird. However, it crossed the Canadian Rockies and turned southward near Lesser Slave Lake in Alberta. By October 16, the bird passed Saskatoon, Saskatchewan, and on October 22, crossed into northeastern Montana. The eagle remained there until the last transmission on January 18, 1993.

Most golden eagles in interior and northern Alaska are migratory. While these birds may spend as much as 5 months (October through March) away from their breeding grounds, they follow unknown migration routes and winter in unknown locations. Mike Kochert of the Bureau of Land Management in Boise, Idaho, commented in a 1994 conversation that some researchers feel that winter food supplies may be an important factor determining reproductive success of golden eagles. Determining the wintering locations of golden eagles from Denali, therefore, has become an important objective of the current nesting ecology study. Our data, collected by satellite telemetry and banding during this study, provide the only data on migratory pathways and wintering areas of juvenile golden eagles from Alaska.

Bald eagles in Glacier Bay, Alaska

In 1991, Glacier Bay National Park and Preserve and the U.S. Fish and Wildlife Service (FWS) began monitoring the long distance movements of bald eagles using satellite telemetry. The park asked us to determine the movements of adult and fledgling eagles from Glacier Bay, identify their wintering sites, and evaluate the feasibility of using satellites to monitor the movements of free-ranging eagles.

We tagged three adult bald eagles with PTTs in October and November, 1991, and also tagged three and four 8-10 week old nestlings in August 1991 and July 1992, respectively. We attached the 76-157 g (2.7-5.5 oz) PTTs, with an estimated battery life of 12 months, using a backpack harness. We also attached 18 g (0.6 oz) tail-mounted conventional VHF transmitters to the adult eagles to confirm the satellite determined locations.

Adult bald eagles remained near their nests on a year-round basis with short forays to salmon streams inside and outside the park. Two of the three adults traveled to the Chilkat Bald Eagle Preserve, over 60 km (36 mi) northeast of Glacier Bay, for 1-2 months. Using conventional telemetry at the Chilkat River, we found and visually confirmed locations of the adults obtained by satellite. After visiting the bald eagle preserve, both eagles returned to their nest sites in Glacier Bay where we again verified their presence using conventional telemetry.

Fledgling bald eagles left Glacier Bay for a longer period and moved away from the park in a southeasterly direction. Six of the seven fledglings left the boundaries of the national park and preserve and were not located there again. Within 4-6 weeks of fledging, four of the fledglings traveled to the bald eagle preserve where they remained for 1-3 months before leaving in a southeasterly direction. We subsequently located the four fledglings throughout southeast Alaska, with one traveling to Prince Rupert, British Columbia, a distance of over 430 km (267 mi) from its natal territory in Glacier Bay. One fledgling eagle appeared to remain in Glacier Bay throughout the winter and early spring. This young eagle moved between its natal territory and various salmon streams in and near the national park.

By using satellite-monitored transmitters, we recorded the movements of both adult and fledgling eagles as they moved within and outside the park. These patterns were similar to those seen in other bald eagles studies in southeast Alaska. We determined that Glacier Bay bald eagles are not year-round residents and identified the areas outside the park that they used. Bald eagle management must transcend park boundaries and include not only regional, but also national and international concerns.

Gyrfalcons on the central Seward Peninsula, Alaska

In 1992, the National Park Service began a study of the autumn and winter movements of juvenile gyrfalcons (*Falco rusticolus*) from the Seward Peninsula in western Alaska as part of the shared Beringian heritage program. In 1992, we tagged two gyrfalcons with 45 g (1.6 oz) PTTs in a pilot study to determine if these birds could be tracked by satellite. The 1992 results were successful and in 1993, we continued the work by tagging seven juvenile gyrfalcons from three nests. This

time we used 30 g (1.1 oz) PTTs attached with backpack harnesses. We observed the falcons carefully after attaching the PTTs and found that birds appeared to fly normally with no noticeable negative effects from the PTT or harness.

We are very excited by the results from this research as they are the first to document regular movements of gyrfalcons between Alaska and Russia. Four of the nine radio-tagged birds crossed the Bering Strait and moved into eastern Russia within 4 weeks of fledging; three of the four eventually returned to winter in Alaska. One bird, however, moved over 3,500 km (2,170 mi) along the southern coast of Russia and wintered in the Shantar Island region in the Sea of Okhotsk (fig. 2). Although banding data documented a similar long distance movement of a juvenile gyrfalcon from the Seward Peninsula to the Kamchatka Peninsula in 1971, only satellite telemetry provides a means to document the entire migratory route.

Other new or noteworthy observations included the lack of directionality in the movements of the juvenile gyrfalcons from the natal area, the independence of sibling movements, movements of juvenile gyrfalcons corresponding to changes in the abundance of prey, long distance movements of juvenile gyrfalcons within 3 months of fledging and the tendency of juvenile gyrfalcons to use coastal and riparian areas, where prey may be more abundant, in autumn and winter.

These results provide the most current information on the movements of juvenile gyrfalcons in Alaska. Of the nearly 500 gyrfalcons banded in Alaska only five have been recovered away from their original banding site (Swem et al. 1994). While these recoveries provide important data on the movements of Alaskan gyrfalcons, the logistical costs associated with banding 500 gyrfalcons over 20 years are staggering. Results from the current study show that satellite radiotelemetry is a cost efficient and effective research tool for studying the movements of large birds in remote areas.

Peregrines in Yukon-Charley Rivers National Preserve and Glen Canyon National Recreation Area

In 1993, the National Park Service and the U.S. Fish and Wildlife Service began a cooperative study of the autumn and winter movements of adult female peregrine falcons *(Falco peregrinus anatum)* that breed in Yukon Charley Rivers National Preserve, Alaska, and Glen Canyon National Recreation Area, Utah and Arizona. In 1993, we tagged two birds from each breeding area with 25-30 g (0.9-1.1 oz) PTTs after the breeding season in a pilot effort to determine if satellite telemetry was feasible to study their migration. Upon release, the birds appeared to fly and hunt normally and seemed unaffected by the transmitter and harness (fig. 3).

Figure 4 on page 24 shows the migration routes of the study peregrines. We tracked the birds through the fall and winter and found that one of the Alaska birds departed in late August and migrated through central North America to southwest Florida where it wintered. The other Yukon-Charley falcon also departed in late August and migrated through central North America, continuing through Mexico to its wintering site in eastern Honduras. In September, the first Glen Canyon bird migrated to the west coast of Mexico, and in early October, we lost its signal. The other Alaskan falcon also departed in September and spent several weeks on the west coast of Mexico before continuing to its wintering site in Nicaragua.

Three of the four pilot study peregrines returned to their territories to breed the following spring and summer. Two were still wearing their PTTs, batteries exhausted, which we removed upon recapturing the birds. The birds appeared healthy and showed no signs of wear or ill effects from the harness or PTT. The fourth bird, identified by its coded color band, had dropped its PTT. We refurbished the recovered transmitters with new batteries (at a cost of $100) for future use.

We initiated the full study following the success of the initial tracking efforts with additional funding provided by the Air Force through the Department of Defense Legacy Resource Management Program. The objectives of the ongoing research are to document the autumn migration routes, any important stopover sites, and wintering areas of peregrines from the two study areas. We will also document and compare

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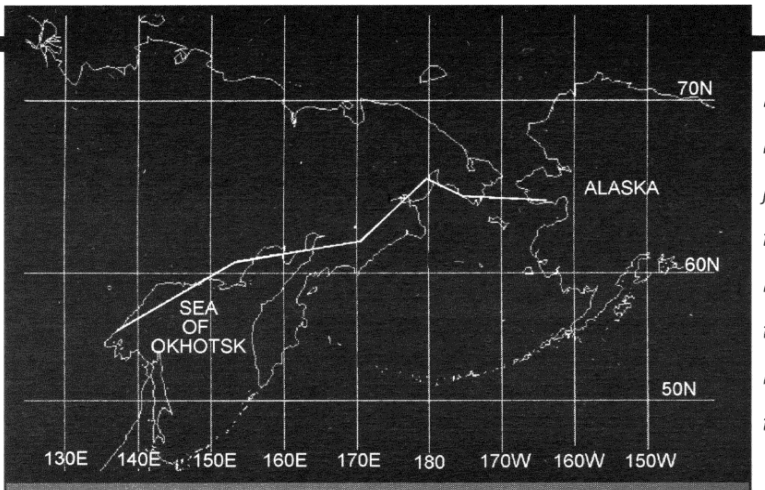

Figure 2. Movements of a juvenile gyrfalcon from Seward Peninsula, Alaska, to Shantar Island, Russia, September to October 1993.

Figure 3. Peregrines in the Alaska and Glen Canyon studies flew without signs of discomfort or hindrance while wearing the satellite transmitters.

differences in migratory patterns and behavior between the high latitude breeding population in Yukon-Charley and the temperate latitude population in Glen Canyon.

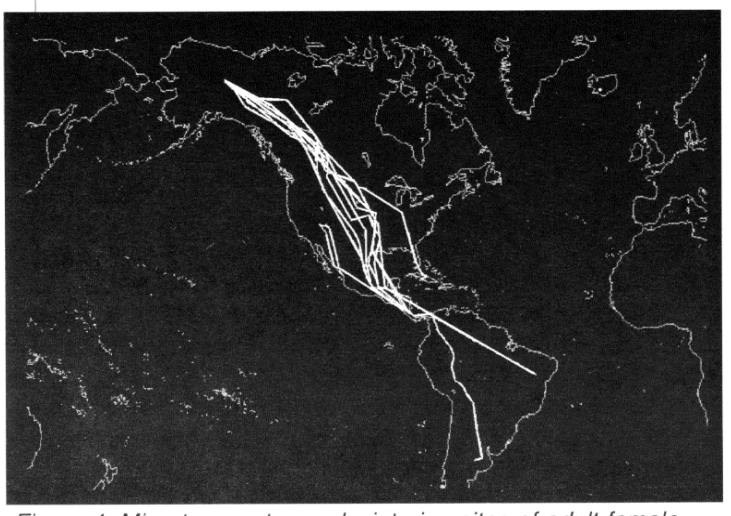

Figure 4. Migratory routes and wintering sites of adult female peregrine falcons from Yukon-Charley Rivers National Park and Preserve and Glen Canyon National Recreation Area. Routes from the pilot fall 1993 to winter 1993-94 study are labeled; all other routes are from peregrines studied the following autumn and winter.

In July 1994, we deployed PTTs on 11 adult female peregrines in Yukon-Charley. Three of the birds appeared to drop their transmitters in the park before migrating. The others left the area in late August, with one traveling to British Columbia before we lost its signal. The remaining seven birds migrated to their wintering areas in Cuba, southern Mexico (two birds), El Salvador, Costa Rica, Brazil, and Argentina (fig. 4).

Results of this study indicate that the wintering range of Yukon-Charley peregrines is larger than suggested by band recoveries; more birds winter in Central America and the Caribbean than previously known, and at least some of the Glen Canyon peregrines migrate and leave the United States in the fall and winter. The only previous data, four band recoveries, give no indication that peregrines in the southwest leave the country in winter. Our results shed light on the risks of pesticide contamination to peregrines along their migration routes and on wintering grounds, areas where the use of dangerous pesticides is not regulated as strictly as in the United States. This information bears directly on consideration of proposals to reclassify the peregrine falcon under the Endangered Species Act.

Conclusions

Satellite radiotelemetry proved to be the most efficient research tool available for these projects and will be extremely useful to other researchers interested in the broad-scale movements of larger birds and mammals. The equipment and data costs are high, but the cost per location may often be less than conventional VHF telemetry. The relative cost depends on the species involved and the size, terrain, and remoteness of the study area. Satellite telemetry allows researchers to follow animals almost anywhere regardless of ecological conditions and political boundaries and reduces the number of animals that must be marked to answer most research questions.

Technological advances are also making satellite telemetry more useful. Recently, satellite transmitters have been coupled with global positioning system units to allow extremely accurate locations to be relayed automatically by satellite. In the near future, smaller (20 g or 0.7 oz) PTTs and lightweight solar powered transmitters will be available, including ones with additional sensors (e.g., altitude). Finally, as demand increases, PTTs and satellite telemetry will become less expensive and more important as a tool for wildlife studies. PS

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Skip Ambrose of the FWS Fairbanks office initiated the peregrine, gyrfalcon and golden eagle studies. Layne Adams with the NPS Alaska Regional Office participated in the gyrfalcon and golden eagle studies. James Fraser of Virginia Polytechnic and State University helped with the golden eagle study, and Dr. Patricia Kennedy of Colorado State University assisted in the peregrine study.

The Hawksbill Turtles of Buck Island Reef National Monument:

A Shared Caribbean Resource

By Zandy-Marie Hillis

Situated near the Caribbean island of Saint Croix in the U.S. Virgin Islands, Buck Island Reef National Monument is home to a small population of nesting hawksbill sea turtles *(Eretmochelys imbricata)*. Interested in their nesting activities and seasonal and long-term migration patterns, we began to research the turtle in 1988 using a mark-recapture tagging technique. Our ultimate goal is to develop an effective management strategy for this endangered species.

In the mark-recapture phase of the project, park staff conducted nightly nesting beach patrols each July through October from 1988-94 and found hawksbill turtles returning to nest both within the season and following multiyear intervals. During this time, we tagged 81 individual nesting hawksbill turtles. Of these, 41 have returned to the park for one or more breeding seasons. The majority of nesting females returned to nest on an average of 2- to 4-year intervals, with only one female returning in 1994 after just 1 year. According to cumulative recapture data, we can anticipate that 50-80% of all tagged hawksbill turtles will return to nest in the park in a subsequent season.

Even after prolonged periods of absence, individual turtles exhibit a very high degree of fidelity to park nesting beaches and to specific sections within the 1.4-km long (0.9 mi) nesting habitat. These sections, approximately 300-m (328-yd) long, equal the average length of any one of the three distinct park nesting beaches, and are defined by eroded berms, fallen trees, and rock walls or cliffs. Hawksbill turtle nesting fidelity is comparable to that reported for green, loggerhead, and flatback sea turtles. This emphasizes the need for careful management of all sea turtle nesting beaches.

Although hawksbill turtles had proven their fidelity to Buck Island Reef during our study, we had no clue as to where they were coming from. When the program first began, local information and other NPS marine field census studies indicated little to no sightings of adult hawksbill turtles around the monument prior to or after the nesting season. To date, no hawskbills have been seen around either Buck Island Reef or Saint Croix outside the breeding season, and none of the park-tagged turtles have been observed nesting at other patrolled rookeries in the Caribbean.

> *Despite their fidelity to Buck Island Reef, we had no clue where they were coming from*

In 1991, the National Marine Fisheries Service Miami Laboratory reported that the national monument-tagged hawksbill "QQD-033" was recovered from the Miskito Cays, Nicaragua, Central America. A student there had purchased the tag and returned it to the National Marine Fisheries Service return address. We believe that this hawksbill was captured by a fisherman, and we presume it is dead. This was our first monument tag recovery, and the long distance traveled by the turtle automatically raised questions about species migratory range. Individual hawksbill turtles repeatedly return to nest at the monument, and we now had preliminary evidence that they were traveling vast distances to do so.

In 1991 and 1992, we conducted both radio and satellite telemetry tracking studies to identify turtles locations between nestings and to determine whether or not they migrate between feeding and nesting areas. From both boats and stations ashore, we tracked the turtles using radio and sonar telemetry. We found that nesting females reside in nearshore waters (within 1-1.5 km of the monument) between nestings. At the end of the nesting season, after laying three to five egg clutches, four turtles fitted with transmitters disappeared beyond radio range. During the 1992 season, a cooperative NPS-U.S. Fish and Wildlife Service satellite tracking study of seven nesting turtles showed that nesting females dispersed from the park to different regions in the Caribbean at the end of the nesting season. All evidence indicates that hawksbill turtles nesting on Buck Island Reef National Monument do not live in the adjacent reef environment, but are migratory!

Marine turtle conservation is not accomplished solely in the isolation of a nesting beach. To be sure, Caribbean nesting beach studies must organize efforts by standardizing field methodologies and reporting tagging study results to a common regional database where tag recoveries can be coordinated. Studies also need to determine the location of feeding grounds and migratory routes to and from nesting beaches, and provide for their protection. The information gathered by the park and other Caribbean hawksbill projects is critical to understanding our shared hawksbill turtle population and is essential to the management and preservation of this highly migratory species. Finally, this research emphasizes NPS long-term responsibility in maintaining the hawksbill nesting and foraging habitats at Buck Island Reef National Monument.

Zandy-Marie Hillis is with the National Park Service and can be reached at Buck Island Reef National Monument, P.O. Box 160, Christiansted, Saint Croix, U.S. Virgin Islands 00821-0160, (809) 773-1460.

An Investigation of Sediment Sources Affecting Marine Resources at Virgin Islands National Park

By Donald M. Anderson and Lee H. MacDonald

Virgin Islands National Park encompasses more than half of the 50-square kilometer (19-square mile) island of Saint John in the West Indies of the Caribbean. The park also incorporates 23 square kilometers (8.9 square miles) of surrounding marine waters. Popular with tourists, the national park offers a tropical setting, white sand beaches, and diverse ecological communities, including coral reefs. In 1976, UNESCO designated the park an international biosphere reserve, thus focusing additional scientific attention on the natural resources of the island.

Unfortunately, valuable park natural resources are threatened; declining health of the coral reefs surrounding Saint John is of particular concern to park managers. Investigations suggest that coral growth rates have slowed substantially this century (Hubbard et al. 1987). Increased production and delivery of fine sediment to the marine zone is one suspected cause, as coral reefs are highly susceptible to chronic increases in suspended sediment and turbidity (Rogers 1990).

Accelerated development of private and public lands on the island is a likely source of sediments to the marine environment. In 1993, we initiated a study of sediment sources and transport on Saint John through a cooperative agreement with the NPS Water Resources Division and with the help of Trish Patterson of the Southeast Regional Office. The principal objectives were: 1) to identify and map areas of low, medium, and high erosion susceptibility; 2) predict delivery rates of sediment to the marine environment; and 3) recommend practices for minimizing erosion and sediment delivery to the offshore zone. We also wanted to develop a set of analytical procedures integrated with a geographic information system that could be used by the park and the territorial government to assess erosion hazards and sediment sources.

Erosion and sedimentation on Saint John

Saint John is a rugged island characterized by small, steep watersheds, intermittent streams, and many small bays (fig. 1). Over 80% of the island has slopes in excess of 30%. The island supports predominantly dry evergreen and moist forest vegetation, the distribution of which is strongly influenced by elevation and the persistent easterly trade winds. Soils are generally very shallow (<50 cm or 20 in) and exceptionally stony.

The brief field component of our study in late 1993-early 1994 focused on assessing the relative importance of different erosion processes on Saint John and evaluating current sediment delivery rates in a historical context. The excavation of a 40-year-old sediment basin, the assessment of long-term sediment accumulation in conjunction with sea level rise, and the analysis of sediment data from other studies (e.g., Nichols and Brush 1988) led us to conclude that long-term sediment yield, under natural conditions, is about 20, and no more than 40, metric tons per square kilometer per year (57-114 short tons per square mile per year, respectively). This is quite low in comparison to rates reported for many tropical environments (Anderson 1994).

The low rate of erosion and sediment yield on Saint John is probably due to predominantly dry soil conditions (a result of generally brief showers and high evapotranspiration rates), associated low rates of bedrock weathering, and ubiquitous stony soil surfaces that protect the soil against rainsplash and runoff erosion. Our field reconnaissance and inspection of air photos also revealed that landslides and debris flows are unusual on Saint John, despite the very steep slopes and occasionally heavy rainstorms.

In contrast, human activities have greatly accelerated erosion and sedimentation rates (fig. 2). Our observations indicate that although plantation agriculture was a significant sediment source in the 18th and 19th centuries, the rapidly-growing network of unpaved roads is by far the greatest source today. We estimate that more than 100 km (62 mi) of roads exist on Saint

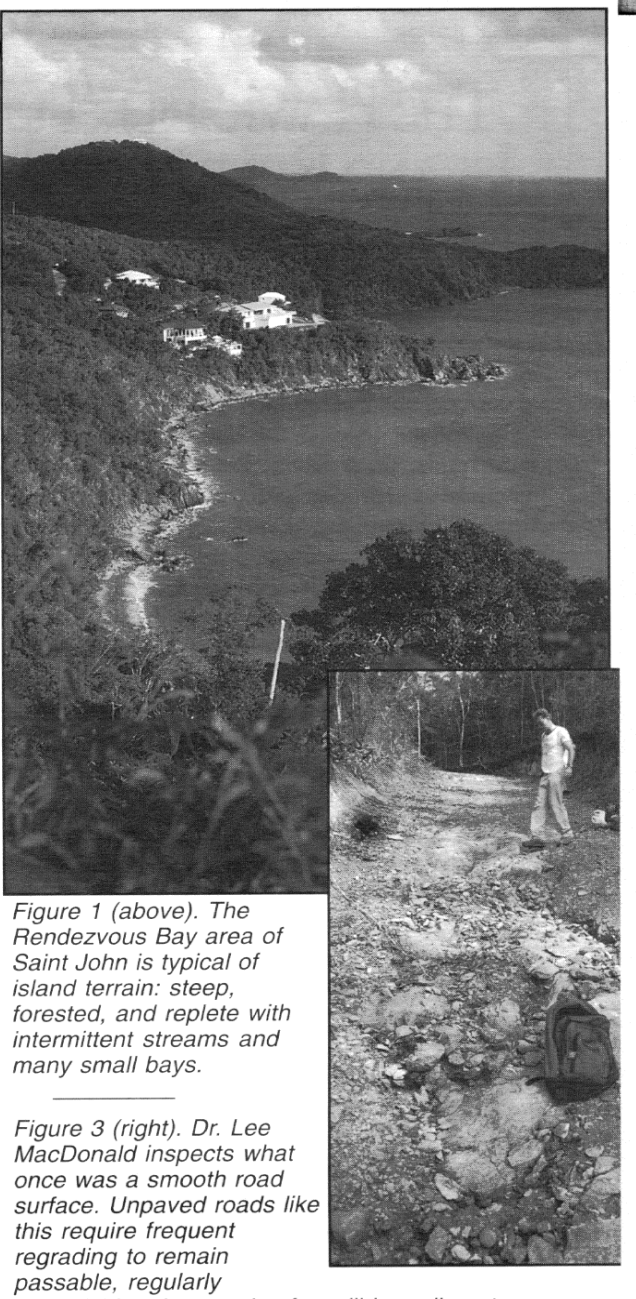

Figure 1 (above). The Rendezvous Bay area of Saint John is typical of island terrain: steep, forested, and replete with intermittent streams and many small bays.

Figure 3 (right). Dr. Lee MacDonald inspects what once was a smooth road surface. Unpaved roads like this require frequent regrading to remain passable, regularly replenishing the supply of erodible sediment.

Figure 2. Approximately 50 km (31 mi) of unpaved roads, many of them crudely bulldozed on steep terrain, traverse Saint John Island; they provide a ready source of erodible soil to be carried bayward during longer-duration rainstorms.

John, and that less than half of these are paved. These roads, many of which are crudely bulldozed access routes to homes, are commonly established at grades of 10-20%. The deeply incised road surfaces, obvious instability of sidecast material, and large quantities of accumulated sediment attest to the severity of road erosion (fig. 3). Unpaved roads on Saint John generally require frequent regrading to remain passable to vehicles, and this regularly replenishes the supply of readily erodible sediment.

Modeling road sediment production

Many studies in temperate and tropical environments show that roads often are the primary source of sediment from rural and forest lands (e.g., Hafley 1975; Ward 1985; Scatena 1993). Road-derived sediment can be generated in a variety of ways, including the erosion of cut and fill surfaces, landslides caused by alterations in slope drainage and stability, and erosion from road surfaces. Our study focused on the latter mechanism, as this was the most obvious and probably largest source of road-derived sediment on Saint John.

We estimated road surface erosion rates at various sites by measuring the cross-sectional road erosion and determining the time since the road was last graded. These measurements indicated that at least 1-2 cm (0.4-0.8 in) of material erodes from the surface of most unpaved roads each year. The erosion rate increases as the runoff-contributing road surface area increases and slope steepens. Figure 4 shows the erosion rate results from 23 study sites in one 6.1-square kilometer (2.4-square mile) catchment.

Linear regression indicates that road grade and drainage area together explain 51% of the variance in road surface erosion (expressed in cubic meters of removed material per linear meter of road per year). Other variables such as road use and road surface characteristics would probably account for some of the unexplained variability in the figure. Unfortunately, limited field time precluded a quantitative investigation of additional variables.

We formalized and largely automated our estimation procedures by writing a program in C, a popular computer programming language, that integrates the regression relationship illustrated in figure 4 with road data compiled using a commercial GIS package (Anderson 1994). This program, called ROADMOD, will allow the park to predict the quantity and location of sediment delivered from a specified road network. Required input data include the width, slope, surface, and drainage characteristics of each road segment.

We applied ROADMOD to road data gathered in the Fish Bay watershed of Saint John (fig. 5–page 28). This catchment has been subject to extensive home building and road construction. Careful mapping of all roads and culverts in this catchment allowed us to estimate the total road surface erosion and the portion of this sediment that is delivered into and through the stream network. The results suggest that road surfaces are responsible for approximately a fourfold increase in average annual sediment delivery to Fish Bay. This is a conservative estimate and does not include erosion from road cuts, fill slopes, or other development activities.

Taking these and other factors into account, we estimate that unpaved roads are increasing the islandwide amount of sediment delivered to the marine environment by a factor of two to ten. This finding has crucial ramifications for resource protection at the park.

Modeling surface erosion susceptibility

At NPS request, we also produced a map showing relative surface erosion susceptibility on Saint John. The purpose of this map is to help land managers identify areas that are particularly susceptible to erosion should vegetation be removed.

We determined erosion susceptibility from three variables: surface erodibility, hillslope gradient, and contributing drainage area. We determined surface erodibility from soil maps and descriptions provided by the Natural Resources Conservation Service (former Soil Conservation Service). Slope gradients and drainage areas for a 10 x 10 m grid of the entire island were estimated using digital elevation data and automated GIS terrain analysis techniques. We included no vegetative cover factor, because we were interested in the likely erosion rate following clearing for development or other purposes.

We used a modified version of the revised Universal Soil Loss Equation (Renard et al. 1991; Moore and Wilson 1992) to predict spatially distributed erosion susceptibilities. Although this equation is not designed or fully validated for steep, forested, tropical regions, it is a widely accepted tool for assessing relative erosion potential. The

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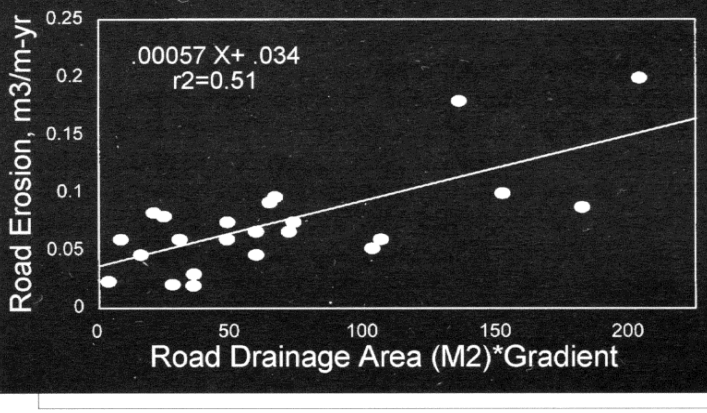
Figure 4. Erosion rates on unpaved roads in the Fish Bay catchment show a correlation with road grade and contributing road drainage area. Erosion increases with slope (in decimal percent) and road surface area (in square meters).



sensitivity of our predictions to topography and the resulting patterns of surface runoff give us some confidence that this map can help land managers guide development away from areas most prone to surface erosion.

Sediment control practices

Because roads have a disproportionate impact on terrigenous sediment production (oceanic sediment derived from land sources) on Saint John, most of our recommendations address this source. For example, we recommend against the construction or widening of additional roads on the island, and we recommend that existing dirt roads be paved as soon as possible.

Other recommendations address the development review procedures currently in place for the territory of the Virgin Islands. For example, we are troubled that proposed subdivision developments on Saint John are not, as of this writing, subject to a formal public review, despite the great public interest in maintaining healthy marine ecosystems. Effective protection of the marine resources at Virgin Islands National Park will require coordinated efforts by both the National Park Service and the Virgin Islands territorial government.

Follow-up work

This project is part of a larger NPS investigation into the effects of land use on marine resources at the park. Complementary work includes a paired watershed study of stream discharge and sediment delivery by the U.S. Geological Survey, and the collection of turbidity and other water quality data around Saint John by the National Park Service.

The progress we made in identifying and quantifying sediment sources on Saint John greatly enhances our understanding of park marine sediment delivery problems, but much remains to be done. For example, the delivery of sediment from hillslopes, stream channels, salt ponds and mangrove lowlands to the marine environment remains poorly understood. Sediment production from road cuts, fill slopes, and roadside ditches also merits further investigation.

The National Park Service, the National Biological Service, the nonprofit Island Resources Foundation, and the U.S. Environmental Protection Agency have expressed interest in supporting additional research of these issues, and we hope that valuable follow-up work will be performed. However, the results to date already point to the primary source of accelerated sediment production on Saint John. Problems caused by roads can and should be immediately corrected if the marine resources of Virgin Islands National Park are to be adequately protected for future generations. PS

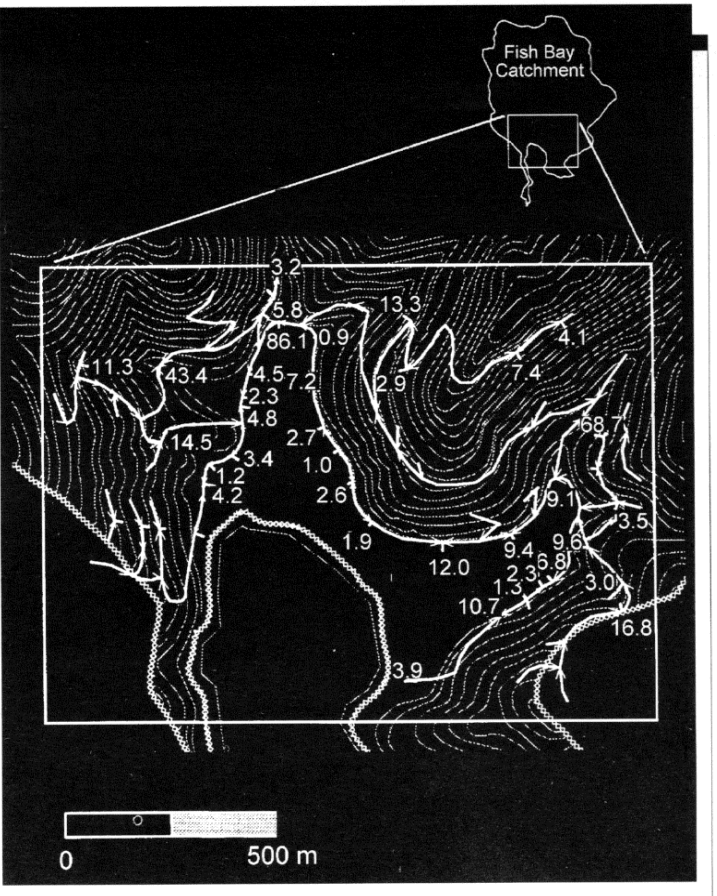


Figure 5. Road sediment delivery map of Fish Bay predicted by ROADMOD. Heavy lines represent the road network, dotted lines the elevation contours, and numeric values the road sediment delivery volume in cubic meters per year. Roads in the lower left part of the map are paved and have no sediment delivery values.

Donald Anderson is a Hydrologist with the National Weather Service National Operational Hydrologic Remote Sensing Center in Minneapolis, Minnesota, and is a recent M.S. graduate of the Colorado State University Watershed Science Program. Lee MacDonald is an Associate Professor of Land Use Hydrology in the Department of Earth Resources at Colorado State University, Fort Collins, Colorado. Dr. Bill Dietrich of the University of California at Berkeley provided invaluable assistance during the field component of this project. Virgin Islands National Park and the Island Resources Foundation provided important logistical support.

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NBS Science Centers: Networking a Key for Technical Assistance

Agencies armed with the best knowledge of NBS structure and a good understanding of agency science centers are likely to receive the best service

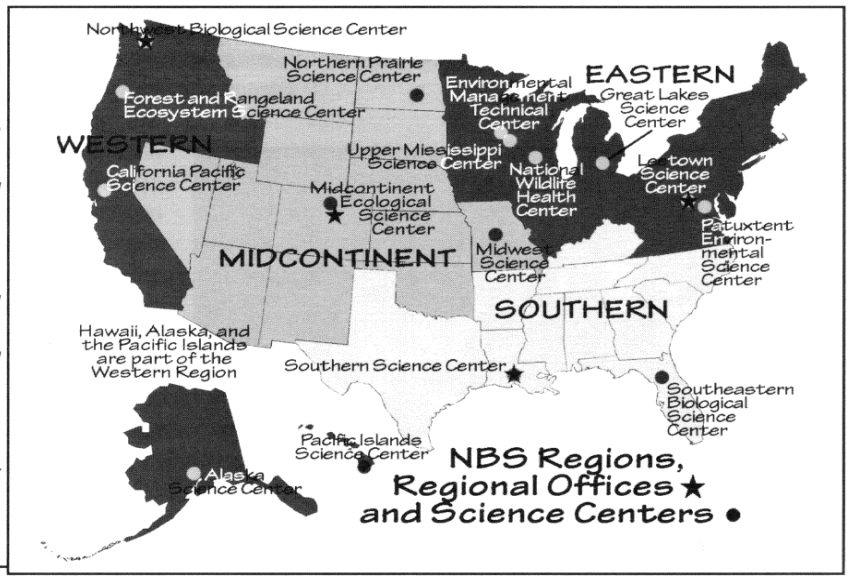

Figure 1. NBS regional boundaries, regional offices, and science center locations.

By the editor

The National Biological Service began operating in November 1993 with staff from the National Park Service, Fish and Wildlife Service, Bureau of Land Management, U.S. Geological Survey, Bureau of Reclamation, and others, to provide the scientific understanding and technologies needed to support sound management and conservation of national biological resources. Several major objectives figured in the formation of the agency: to increase efficiency in providing biological information and support to land managers, to improve objectivity in research, to anticipate and avoid ecological disasters while enhancing natural resource management, and to improve data quality.

In its first year-and-a-half, the agency has worked toward the difficult task of creating an organization that satisfactorily serves all client agency needs. In this time, high quality long-term research has progressed nicely; however, technical assistance has fallen well below our needs. For parks to be successful in getting good technical assistance requires that we tell them our needs as identified through the resource management planning process. To do this, we need to know how they are organized and who to call.

The National Biological Service is organized around a directorate in Washington, D.C., that handles the programmatic areas of research, information and technology services, inventory and monitoring, and several administrative functions. To carry out most of the activities related to research and technical assistance, the agency formed four regions, Western, Midcontinent, Southern, and Eastern, (fig. 1) whose regional directors entered on duty in February. Regions are organized geographically, and generally render assistance to client agencies from the states that make up the region. Within regions the NBS operates science centers, an agency strength, that manage the research (the biggest program area), inventory and monitoring, information and technology dissemination, and technical assistance activities in support of client agencies. NPS resource managers may be unfamiliar with science centers as the centers grew up under the Fish and Wildlife Service.

Science centers are one of two *hubs* of biological research within the agency and generally coordinate projects within regions by broad ecosystem type (e.g., riparian, montane, grassland areas, etc. [figure 2 on page 30]) or discipline (toxics and aquatics systems, Great Lakes fisheries, vertebrates, wildlife diseases, etc.). In this analogy, field stations are the *spokes* with more specific research scopes (the Colorado Plateau, Glacier National Park, etc.). The four regions can be thought of as the *wheels* and along with their support units they make up the *vehicle.* Altogether, the NBS operates 15 science centers and 88 field stations, many located within national parks.

Another research hub that complements the science centers and their affiliates is the NBS Division of Cooperative Research. Administered nationally, this umbrella organization includes all 60 NBS cooperative research units. Among this group are Cooperative Fish and Wildlife Units that came to the National Biological Service from the U.S. Fish and Wildlife Service, a Raptor Research Unit from the Bureau of Land Management, and 12 Cooperative Park Studies Units dedicated to national park system areas that we provided. We can request research and technical assistance from any of these units, but CPSUs focus on parks, while the fish and wildlife units focus on broader ecological questions. Altogether, the 60 cooperative research units add to vehicle momentum through their parallel research and support efforts.

Using science centers

Science centers are very diverse and vary somewhat in expertise and areas of geographic responsibility, although all perform biological research, conduct inventory and monitoring activities, provide some technical support, and produce information products for land managers (see table 1 on page 31). One highly specialized center, the National Wildlife Health Center in Madison, Wisconsin, has expertise in wildlife diseases and serves the entire country. In cases not involving these specialized centers, a research project may still be special-

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ized enough, as in the case of migratory birds, to warrant disregard of regional boundaries. Thus, while research is generally organized and managed regionally, the NBS is flexible in providing specialized services across regional boundaries. A problem that we need to work through in the coming years is that some regional centers are so specialized that they cannot serve our broad needs.

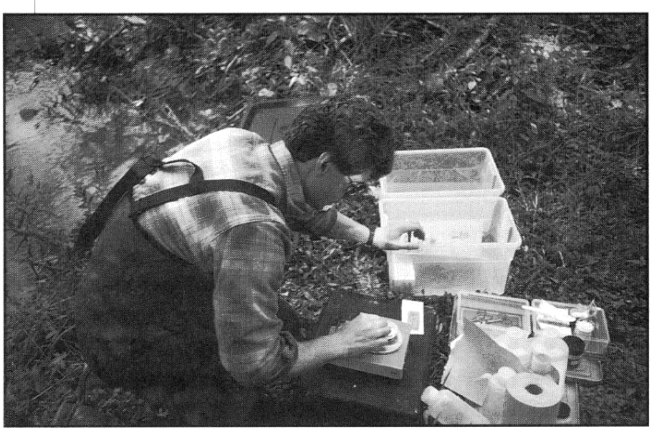

Figure 2. This Midcontinent Ecological Science Center researcher has set up a streamside surgical center *for use in a cool water stream ecology fish tracking study.*

This paradigm of organizing around state boundaries at one level and ecosystems at another appears to be useful, if not somewhat complex. In our own reorganization we have adopted a comparable scheme, although not congruent with that of the National Biological Service. An example of NPS-NBS regional incompatibility to be aware of might involve our proposed restructured Central Region. This region would have to deal with three NBS regions to accomplish research or technical assistance through the NBS. For example, the NBS Midcontinent Region would correspond to the Great Plains states of our Central Region. The NBS Eastern Region would correspond to our Great Lakes parks. And the Southern Region of the NBS would serve our Central Region for Arkansas areas. Conversely, parks in Nevada (new NPS Western Region), North Dakota (Central Region), and New Mexico (Intermountain West Region) would all be served by the NBS Midcontinent Region (although possibly by different science centers). In this scenario, the NBS would deal with three NPS regions and several system support offices. As we inaugurate our new organization in the coming months, this kind of administrative inconvenience must be anticipated in order to enable us to form productive working relationships with the NBS.

How to request technical assistance from an organization that rewards pure research and has no single process for responding to technical assistance needs is not simple; finding technical assistance for the near future will likely require ingenuity, networking, and good communication. First, parks might call the science centers that have geographic responsibilities or specialized expertise relevant to their area to secure a prospectus describing the center, its services, products, and areas of expertise. Much of the information presented in the article profiling the Midcontinent Ecological Science Center came from their prospectus. This kind of document is very helpful in gaining a general orientation to the work and scientists of the center. One of its most helpful features is an index to expertise that is presented in the back of the booklet. By looking up a keyword related to the kind of expertise needed one can quickly reference the correct section at the center to contact.

Another idea is to get in touch with the two NBS information and technology services divisions in Colorado. The NBS information and technology mission is to provide leadership in the development, production, publication and use of a variety of different instruments to transfer pertinent resource information, data (spatial and nonspatial) and techniques among Department of the Interior personnel, NBS partners, and the national and international community of resource managers. Two centers are focal points for these efforts: the Fort Collins, Colorado, Information Transfer Center, (303) 226-9401; and the Technology Transfer Center in Lakewood, Colorado, (303) 969-2590. The latter supports the infrastructure needed to communicate data and has less direct contact with client agencies, while the former can search databases of biological information and projects to help put NPS resource managers in touch with appropriate NBS personnel.

National Park Service regional chief scientists are also a primary resource for field resource managers to contact in seeking NBS technical assistance. Serving as research liaisons, chief scientists can make suggestions on who to call at a science center for a particular area of expertise. Unfortunately, we do not presently know who will perform the science coordination function at either the system support offices or field director offices beginning in May. Another good approach would be to contact appropriate cooperative unit or field station personnel to ask their advice about the correct person to call for assistance.

The technical assistance arena is much less formal than the area of long-range research planning. Consequently, requests for technical assistance can be made at any of several NBS organizational levels: field station or cooperative research unit, science center, region, or national office. Short duration requests (of just a few days) can often be handled at lower levels of the organization. More involved requests may be forwarded further up the line, as appropriate. Requests that enter at a higher-than-appropriate level are reassigned to the appropriate level. Still, parks should try to make technical assistance requests directly to the appropriate level. Once a request for assistance becomes more involved than requiring a few days of help, a more formal arrangement, such as an interagency agreement or memorandum of understanding, may be necessary.

A park that finds the assistance it is looking for (at science centers, field stations, or CPSUs) may receive all project funding to go with it or may be asked to pay for a portion. At the science center level, several funding scenarios are possible with room for some negotiation. Whatever course is taken in deciding project funding, NBS staff are sure to consider the applicability of research and technical assistance results on lands beyond those of just the requesting park. That is, broader applicability would probably favor higher or total funding.

Conclusion

Our concerns about inadequate NBS technical assistance are being heard by NBS leaders, and we can expect the agency to work toward better service in the coming years. In the absence of a formal system for requesting technical support, park resource managers are encouraged to use their networking and negotiating skills to learn about considerable NBS science center expertise and put it to work in parks. We may need to start by learning who to call and telling them what we need. PS

Table 1. NBS Science Centers

Science Center	Expertise	Address
Eastern Region		
Patuxtent Environmental Science Center	Environmental contaminants, migratory birds, and eastern United States endangered species.	12100 Beech Forest Road; Laurel, MD 20708-4039; (301) 497-5500; (301) 497-5505
National Wildlife Health Center	Research, information, and technical assistance on national and international wildlife health issues.	6006 Shroeder Road; Madison, WI 53711; (608) 264-5411; fax (608) 264-5431
Great Lakes Science Center	Research, inventory and monitoring, and information transfer related to managing, restoring, and protecting organisms and habitats of the Great Lakes basin.	1451 Green Road; Ann Arbor, MI 48105-2899; (313) 994-3331; fax (313) 994-8780
Environmental Management Technical Center	Long-term resource monitoring program for the Upper Mississippi River. Schedule to combine with Upper Mississippi Science Center.	575 Lester Avenue; Onalaska, WI 54650; (608) 783-7550; fax (608) 783-8058
Upper Mississippi Science Center	Ecological, toxicological, physiological, and chemical research related to management of fish and wildlife resources with emphasis on the Upper Mississippi River. Scheduled to combine with Environmental Management Technical Center.	2630 Fanta Reed Road; La Crosse, WI 54602-0818; (608) 783-6451fax (608) 783-6066
Leetown Science Center	Culture, nutrition, genetics, and diseases of anadromous fish; research and studies and monitoring of eastern river systems.	1700 Leetown Road; Kearneysville, WV 25430; (304) 725-8461; fax (304) 728-6203
Southern Region		
Southeastern Biological Science Center	Management and conservation of biological resources in the southeastern United States.	7920 NW 71st Street; Gainesville, FL 32653; (904) 378-8181; fax (904) 378-4956
Southern Science Center	Research development related to protecting, restoring, and managing wetlands, migratory birds, and other natural resources along the Gulf Coast.	700 Cajundome Blvd.; Lafayette, LA 70506; (318) 266-8500; fax (318) 226-8513
Midcontinent Region		
Midwest Science Center	Lead role in NBS for determining existing and potential effects of toxic materials and other aquatic ecosystems stressors.	4200 New Haven Road; Columbia, MO 65201; (314) 875-5399; fax (314) 876-1896
Midcontinent Ecological Science Center	Research and technology development for management of biological systems (species to ecosystems) of the interior western United States.	4512 McMurry Avenue; Fort Collins, CO 80525-3400; (303) 226-9100; fax (303) 226-9230
Northern Prairie Science Center	Ecological requirements of wildlife populations of interior grasslands and prairie wetlands of the United States.	8711 37th Street SE; Jamestown, ND 58401-7317; (701) 252-5363; fax (701) 252-4217
Western Region		
Northwest Biological Science Center	Identification and measurement of environmental factors that limit distribution and abundance of western United States fish, especially anadromous species.	Building 204, NAVSTA; Seattle, WA 98115-5007; (206) 526-6282; fax (206) 526-6654
Forest and Rangeland Ecosystem Science Center	Northwest forest management research, range quality assessment, wildlife-habitat relationships evaluation, and ecosystems models and analysis.	3200 Jefferson Way; Corvallis, OR 97331; (503) 757-4840; FAX (503) 757-4845
Alaska Science Center	Field and laboratory research on fish, wildlife, and their habitats in Alaska and other circumpolar ecosystems.	1011 East Tudor Road; Anchorage, AK 99503; (907) 786-3512; fax (907) 786-3636
California Pacific Science Center	Information and technologies for management of California desert, coastal, and nearshore marine ecosystems.	6924 Tremont Road; Dixon, CA 95620; (916) 756-1946; fax (916) 678-5039
Pacific Islands Science Center	Research, baseline information, and technical assistance related to conservation of indigenous biological resources in Hawaii and the Pacific territories.	Mauna Loa Research Station; P.O. Box 44; Hawaii Volcanoes National Park, HI 96718; (808) 967-7396; fax (808) 967-8568

Meetings of Interest

MAY 15-17

A symposium on outdoor recreation and tourism trends is planned at the Radisson Hotel in Saint Paul, Minnesota in mid-May. It will emphasize international and domestic outdoor recreation and tourism trends, the economics of sustainable outdoor recreation and tourism trends, technology change and new ways to address recreation and tourism planning and management, trends in human dimensions of fish and wildlife planning and management, trail and greenway trends, and other areas. For more information, contact Dave Lime or Jerrilyn Thompson, Cooperative Park Studies Unit, Department of Forest Resources, 115 Green Hall, University of Minnesota, Saint Paul, MN 55108, (612) 624-491-6714.

JUNE 7-11

The annual meeting of the Society for Conservation Biology will take place in Fort Collins, Colorado in June. For more information, contact Richard L. Knight, Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, CO 80523, (303) 491-6714.

JUNE 21-24

A conference on Who Owns America? Land Resource Tenure Issues in a Changing Environment will meet in Madison, Wisconsin, in early summer. Sponsored by the University of Wisconsin, the conference seeks to bring together nontraditional and traditional voices of policy makers, grassroots activists, academic researchers, and citizens interested in ownership, management, and regulation of land and natural resources. Contact Gene Summers of the Land Tenure Center's North American Program at the University of Wisconsin, 1357 University Avenue, Madison, WI 53715, (608) 262-3658, fax (608) 262-2141, e-mail "summers@soc.ssc.wisc.edu".

AUGUST 12-16

The Second International *Martes* Symposium will be held at the University of Alberta, Edmonton, this summer to explore integrating this genus, which includes weasels and skunks, into forest management. Call Dr. Paul Woodward at (403) 492-4413 or Dr. Gilbert Proulx at (403) 464-5228 for further information.

SEPTEMBER 24-27

Ecology and Conservation in a Changing Landscape: Third Biennial Scientific Conference on the Greater Yellowstone Ecosystem will take place at the Mammoth Hot Springs Hotel in Yellowstone. Abstracts are due May 1 and should be forwarded to the Conference Program Committee, Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, WY 82190.

SEPTEMBER 26-29

Co-hosted by the National Park Service, The Midwest Oak Savannah and Woodland Ecosystem Conference will be held in Springfield, Missouri, at the University Plaza Hotel. A working gathering, the sessions will aim to launch a recovery plan for endangered oak savannah ecosystems throughout the Midwest. Contact Sybill Amelon of the Mark Twain National Forest in Houston, Missouri, at (417) 967-4194 for further information.

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