

# PARK SCIENCE

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## Inventory and Monitoring in the National Parks: Forging a Plan

By June C. Rugh and David L. Peterson

*The National Park Service will assemble baseline inventory data describing the natural resources under its stewardship and will monitor those resources ... to detect or predict changes. The resulting information will be analyzed to detect changes that may require intervention and to provide reference points for comparison with other, more altered environments [emphases added].*

— Management Policies, Chapter 4.4, 1988

The NPS policy statement above marks a turning point in the long history of resource inventory and monitoring in national parks. For although inventory and monitoring (I&M) activities — species checklists, visitor counts, weather records — have been conducted in individual parks since the 1870s, only recently has there been an effort to establish a more rigorous and integrated approach to these endeavors. The impetus behind this effort is threefold. First, multiple environmental stresses on parks (including human use, air pollution, introduced species, and a changing global climate) are increasing at an unprecedented rate, making reliable scientific data imperative for effective resource management. Second, there is a growing recognition that coordinating and standardizing I&M activities throughout the NPS would enable managers to track resource conditions on an interpark and nationwide basis, ultimately yielding a higher quality of both I&M data and managerial decision-making. Finally, it is generally acknowledged that for I&M programs to be successful in the long term, the responsibility for coordinating these activities must be tied to positions rather than individuals: they must be incorporated into the NPS organizational structure.

While the NPS is committed to the concept of improved inventory and monitoring, there have been no systematic guidelines until now (see shaded box). Resource managers also need a standardized planning strategy to help them in developing individual park I&M programs. The planning strategy should 1) be generic enough to accommodate a variety of objectives and resolution levels, 2) assist managers with decision-making, including improved quantification, and 3) be flexible enough to be easily modified and updated. The development of such an approach is part of an ongoing research effort by the Pacific Northwest Region to improve I&M programs in the NPS. Research Biologist David L. Peterson and Research Associate David L. Silsbee are directing this effort at the U/WA CPSU, in cooperation with Daniel L. Schmoltdt of the USDA Forest Service, Blacksburg, VA. The planning approach developed by this research team emphasizes the following components:

This article (the first in a series of two) represents a research effort on the part of the Pacific Northwest Region to offer an approach for developing a dynamic, technically rigorous inventory & monitoring program within each park. Based on state-of-the-art methods and analyses, it offers practical strategy and support tools that will facilitate I&M program development among parks. One sign of NPS's renewed commitment to I&M is the recent appointment of Gary Williams to the newly created position of Director of the Service-wide Inventory & Monitoring Program at WASO. A general conceptual model of the inventory and monitoring process appears in the recently published *Natural Resources Inventory & Monitoring Guideline* — NPS-75. For more information, contact Gary Williams, (202) 208-5193.

- An **interdisciplinary team approach** to I&M program development
- **Standardized project description and classification**
- **Development strategy:** objectives and attributes of I&M projects
- **Quality assurance and data management considerations**
- **Support tools** for prioritizing, planning, and allocating resources to I&M projects.

This approach can be used to develop a new I&M program or to modify an existing one. The **interdisciplinary team** of scientists and resource managers would work together intensively to develop program objectives and write a comprehensive I&M plan for the individual park. Standardized **project descriptions** and **classifications** establish a conceptual and technical basis for prioritization and implementation, as well as insuring consistency among parks. **Development strategy** for I&M programs focuses on the objectives and attributes of each project as the keys to implementation. **Quality assurance** and **data management considerations** are addressed as essential factors in maintaining the integrity and scientific validity of each proposed I&M program. Finally, the **support tools** consist of decision-making strategy (the Analytic Hierarchy Process) and interactive computer software, both of which employ a quantitative rating system to assist in planning and prioritizing I&M projects. The same tools serve in the allocation of resources for I&M projects, which is optimized by including information on budget and personnel requirements as part of evaluating and selecting projects. *This final section on I&M support tools will appear in the next issue of Park Science.*

### Interdisciplinary Planning: the Team, the Tools, the Process

One of the most useful innovations in the works is the development of an I&M interdisciplinary planning

**Continued on page 3**

Figure 1. Interdisciplinary team process for developing an I&M plan.

- I. INITIATION OF PROCESS:** *Park staff*  
Contact I&M team leader;  
provide materials
- II. WORKSHOP:** *I&M team & park staff*  
Overview; brainstorming;  
final project list; descriptions
- III. I&M PLAN DRAFT:** *I&M team leader & park staff*  
Compilation of project descriptions;  
overview; tables; references
- IV. REVIEW:** *I&M team, park staff, & others*  
Circulation of draft for review
- V. FINAL I&M PLAN:** *I&M team leader & park staff*  
Final plan written, after reviews

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## editorial

If you build it, they will come.

Watchable Wildlife was the movement; a stylized set of binoculars was the logo; and they came – 400 strong, from all over the U.S. and even from Canada and Mexico – to the 1st National Watchable Wildlife Conference, Sept. 10-12 in Missoula, MT.

For three jam-packed days, representatives of eco-tourism, and federal and state agencies with fish, game, and/or recreation interests, interacted both inside and outside of 34 intensive working sessions. The subjects covered almost every conceivable way of incorporating watchable wildlife into entertainment, enjoyment, education, the economy, and ethics. Whether the individual conferees came motivated to make money or to promote biological diversity, the watchable wildlife theme was inclusive and binding.

Fifteen entities – federal agencies (including the National Park Service) and conservation organizations – were signatories to the Memorandum of Understanding that supports the movement, but none of the 15 evidenced a "guiding hand." Rather, it was the yeasty mix of celebrants, eager to share information and success stories, that provided the conference signature. The working sessions showcased story after story testifying to the public hunger to be involved in wildlife activities.

Hal Salwasser, formerly a deputy director of the U.S. Forest Service and soon to be the Boone and Crockett professor of forestry at U/MT, sounded the upbeat conference note in closing:

"Don't lose the magic," he said. "You're building a coalition here of public and private sectors that can do more than any legislation. You aren't dependent on any agency or leadership group or pot of dollars. You're people from many different places and interests, bringing meager resources to the table and making of them something much larger than the sum of the parts.

"You're excited. You're having fun. You're pulling together. You represent a promising alternative to polarization. You have the enormous task of recreating the old sense of community whose actions are based on collective self-interest.

"So celebrate your successes; share your information. These are goals enough for now."

#### JAMES M. RIDENOUR, Director

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Jean Matthews, Editor; 4150-A S.W. Fairhaven Dr., Corvallis, OR 97333 (503) 754-0263 or (503) 758-8503  
Park Science FAX (503) 737-2668, c/o Forest Resources

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The NPS has produced a Watchable Wildlife brochure that will be ready for distribution by November 1. The 4-color 16 x 16½" folder was funded by the NPS Foundation and the National Fish and Wildlife Foundation. It describes some of the wildlife that can be seen in the 10 NPS Regions.

# Forging a Plan for I&M in National Parks

(continued from page 1)

team at the regional level. Composed of regional office personnel, field unit resource managers, and scientists from CPSUs – as well as experts from outside sources – the team would bring a wide range of professional knowledge to park I&M planning efforts. Working through a five-step process, team members would help resource management staff conduct a thorough review of the management and scientific aspects of I&M projects for the park, while keeping in mind the broader goals of the region and the NPS. Typically, the region's I&M coordinator (already in place or soon to be named in most regions) would be the team leader, overseeing a 10-member group with proven expertise in areas such as terrestrial, aquatic, and wildlife biology, social science, cultural resources, and resource management. One or more team members would also be proficient in quality assurance procedures and data management; other experts would be invited to participate as needed.

As indicated in Figure 1, the initiative to begin the process would come from the park's own resource management staff. On anticipating the need for developing (or revising) an I&M plan, the park's I&M coordinator (i.e., the resource manager with lead responsibility for I&M activities) would contact the regional I&M team leader, also providing the team with enough background material to establish a working familiarity with the park's resources, existing data, and current concerns. The park staff would then convene a workshop, preferably on-site, attended by the I&M team and selected members of the resource management staff. Following an overview, conducted by park staff on resources, scientific issues, and managerial concerns, including field site visits, the team leader would direct workshop participants through these phases: a brainstorming session to voice and record all ideas relevant

to I&M concerns; organizing a list of potential I&M projects; establishing a final, consensual list of I&M projects; and writing a detailed description of each proposed project. The team leader also would introduce planning and decision support tools, including the Analytic Hierarchy Process and related software, and would demonstrate applications for prioritizing projects and optimizing resource allocation.

At this point, park staff participants would be encouraged to draw on the available expertise for rating projects. These ratings would serve as input for park resource management staff, who would have the final word on project prioritization. Following the workshop, the team leader would compile completed project descriptions into a draft I&M plan, including a table of projects with estimated budget and personnel requirements, reference material, and an overview statement prepared in conjunction with park staff. This draft plan would then be circulated for review among the I&M team, park staff, and other appropriate NPS staff. Other interested parties, such as agencies with adjacent land ownership, also would be included in the review process. After consideration of these reviews, the final I&M plan would be prepared by the I&M leader and park staff.

In essence, the interdisciplinary planning group would serve as a "SWAT team," bringing in expert knowledge and tactics to expedite the process and enable resource managers to design I&M programs with the greatest efficiency, consistency, and suitability.

## Project Description and Classification: Finding A Common Language & Organizational Framework

The list of projects developed by the interdisciplinary team must include enough data for each project to provide a conceptual and technical basis for prioritization and implementation. Moreover, individual project de-

scriptions must use a common language in order to guarantee consistency among parks and optimal usefulness within the NPS. To this end, Peterson et al. (1992) have developed a taxonomy of resource categories to be used in I&M planning. At the most general level, the categories consist of headings such as "Atmospheric," "Geologic," "Hydrologic," "Flora," "Fauna," and so on. Subcategories lend further precision, so that the full resource classification for one I&M project might read "Human Activity > recreation > backcountry use > impacts > aquatic resources," with the final subcategory being the most specific, and the full sequence representing a precise picture of the resource in question. Along with taxonomic classification, each project also is classified according to "level of effort" – the amount of effort required to obtain the information required for I&M planning. The three specific levels of effort are: 1) compile existing information, 2) conduct resource inventories, and 3) establish monitoring.

The current as well as the planned level of effort should be indicated. For example, a park that wishes to determine the effects of air pollution on plant species may already have some data on sensitive species (*current*: "compile existing information"), but would like to determine if other sensitive species are present (*planned*: "conduct resource inventories") and evaluate visible symptoms for several years (*planned*: "establish monitoring"). The first level, "compile existing information," does not actually involve any inventory or monitoring of resources. It is nevertheless important both because it prevents wasting time and money collecting information already available and because it provides clues to gaps in data that an I&M project typically encounters. For a full discussion of the specific methods involved at each level of effort, see Peterson et al. (1992). The resource categories and level of effort designations should be considered an organizational framework for classifying and identifying I&M projects in preparation for the subsequent steps of prioritizing, decision-making, and allocating resources.

## Development Strategy: Defining Objectives and Selecting Attributes

The first hurdle in developing an I&M program is defining objectives. Only then can decision-makers move on to deciding which attributes (e.g., air quality, species) to inventory and monitor, and which monitoring protocols to apply. The most common objective is to use I&M information to enable managers to make better informed management decisions. For example, the impact of park visitors on vegetation can be monitored to determine whether changes in visitor management strategies are needed. Another typical objective would be to use I&M information to convince others to make decisions benefiting parks. As shown in Figure 2, the list of major I&M objectives extends to eight, and each of these can be described in concise, functional terms (e.g., "Inform internal decision-makers"). Figure 2 also delineates the relationship between each objective and its respective attributes selection.

Decisions regarding which specific attributes to monitor, and at what level the monitoring should be done, are determined by the governing objective. Inventory and monitoring can be done at any level, from individual organisms to entire ecosystems. A program with the objective of providing early warnings for global or regional problems, for instance, would require focusing on stresses appearing at the individual and

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Figure 2. I&M Objectives and Attributes Selection

Objectives	Attributes Selection
Inform internal decision makers	Attributes involved in specific management decisions
Influence external decision makers	Attributes most likely to show effects of outside activities
Satisfy legal requirements	Determined by legal requirements
Maintain familiarity with resources	Attributes most sensitive to change
Provide better understanding of resources	Broad spectrum of attributes
Provide background information	Attributes of day-to-day interest to visitors and others
Provide early warning of global or regional problems	Attributes most likely to show detectable change
Provide background data for exploited areas	Attributes of interest in managing outside areas

# GIS Analysis Determines Erosion Potential At Buffalo National River Basin

By Tim Stephenson and David Mott

Land use activities in the hilly terrain of the Ozark Plateaus have resulted in widespread erosion at least since the mid 1800s. The principal endeavors here in the late 19th and early 20th centuries were logging, open grazing of hogs, and row cropping in flood plains. More recently, conversion of forest to pasture is the

dominant activity.

Because the Ozark region is dominated by limestone and dolomitic rock types, which typically produce poor soils with a high proportion of gravel sized chert, the dominant land derived sediment resulting from this erosion is soil and gravel. As a result of the gravel's size and mass, it has a relatively long residence time in the surface hydrologic system. Accord-

ing to Jacobson and others (1990), erosion and transportation of sediments has caused Ozark streams to exhibit gravel aggradation and resultant channel instability. By comparing recent and prehistoric periods of aggradation, these authors have concluded that the recent episodes appear to be much more severe.

Aggradation of channel sediments and cleaning of

*Continued on page 5*

## I&M in National Parks

*Continued from page 3*

population level, where these effects would appear sooner than at the community or ecosystem level. Determining which species to monitor involves yet another set of criteria and considerations (for specifics, see Silsbee and Peterson (1991)). Developing specific monitoring protocols for selected ecosystem attributes is relatively straightforward, dictated by cost limitations and the intensity of sampling needed to give useful results.

Throughout this decision-making process, the development of an I&M plan can be expedited and enhanced by using the Analytic Hierarchy Process and the supporting software, Expert Choice<sup>2</sup> (these support tools will be discussed in depth in the subsequent article). Placing the objective (or "goal") at the top of the hierarchy, managers – with the help of the I&M team leader and Expert Choice – can change values randomly or systematically to see how changes in the objective would shift priorities down the line. For example, the relative importance of "support of resource management decision-making" could be high in one case and low in another. Or an emphasis on "provide background information" could be replaced by an emphasis on "satisfy legal mandates." This exercise enables a manager to determine how different management objectives would affect overall project rankings: changing just one element of the hierarchy might cause one project to rise, and another to drop, within the I&M program as a whole. The large and varied amount of information encompassed by the Analytic Hierarchy Process/Expert Choice model structure thus permits a resource manager to examine the conceptual basis for I&M project development and prioritization from many angles, and in great detail.

### Quality Assurance and

#### Data Management Considerations:

##### Preserving the Integrity of the Program

A strong quality assurance (QA) program is the cornerstone of credibility for I&M efforts and insures that I&M data will stand up in a court of law, if necessary. QA provides continuity and consistency over time, among different employees, and through changes in management and personnel. This is particularly crucial for monitoring programs which compare data collected by a variety of people over a long period of time. In the context of an I&M program, QA focuses on the design of a program appropriate to the stated objectives, including the identification and resolution of potential quality assurance problems. Specialized experimental designs may or may not be necessary, but thorough documentation of project objectives, design, and methods is always vital to a QA program. Documentation of the precision and accuracy of all measurements used in I&M activities also is essential.

Each park's I&M coordinator must be aware of QA

concerns and address them explicitly. It is advisable to work with a statistician (as part of the I&M team, or brought in separately) concerning study design, sampling, and statistical analysis. Similarly, scientists with expertise in QA should be contacted for help in developing protocols for the park's I&M projects. Advice on specific QA protocols can be obtained through NPS divisions such as the Air Quality and Water Quality Divisions; other agencies, particularly the EPA, also have expertise in this area.

Every I&M project should include a QA document that correlates with the other elements of the overall I&M plan. The QA plan should include 1) a *description* that explains and justifies the overall approach to the project, including objectives, methods, scope, statistical treatment, and the project's relationship to other studies; and 2) a *methods manual*, including site selection, sampling protocols, data sheets, documentation of precision and accuracy, and data analysis and reporting. Careful documentation must continue throughout the duration of each I&M project, and should include: site descriptions and observations; explanations of deviations from sampling methods; sampling dates and personnel; periodic precision and methods checks of all methods and personnel; and data storage, including frequent duplication and security measures.

Sound data management measures, in turn, are the key to successful QA. The objectives of data management are to insure that 1) data are stored and transferred accurately, and 2) data are secured from loss or damage. Moreover, the structures and format of the data must be documented with sufficient detail so that someone not versed in the original project could interpret their meaning and evaluate their accuracy and precision. For recommended data management measures, see Peterson et al. (1992).

Although the QA and data management aspects of I&M can sound burdensome, they are critical to making a park's I&M program technically sound, credible, and defensible. If such measures are instituted at the start of each I&M project, they will become a routine part of its operation. Because every park unit will not have the expertise to develop QA and data management procedures on its own, it is vital to identify cooperators who have background in this area; this includes personnel from other parks or regional offices and various NPS divisions, as well as from other agencies and universities. Such outreach efforts can open doors to cooperators who would be interested in participating in I&M projects, and can also add facets to the program that the park itself cannot fund. Ultimately, the completeness of QA and data management must be balanced against available funding and labor.

### A Commitment to I&M: Envisioning the Future

The practical strategy and support tools being developed by the Pacific Northwest Region offer an approach for developing an adaptable, technically rigor-

ous program within each park, based on up-to-date methods and analyses. They provide a consistent framework that will assist in standardizing I&M program development among parks on a regional and national basis. In addition, this approach encourages interaction among different units within and outside NPS, in order to address a wide range of scientific and managerial concerns.

The most striking sign of NPS's growing commitment to I&M is the newly created position of Servicewide Inventory & Monitoring Program Director at WASO. As Program Director, Gary Williams has helped to produce the newly published *Natural Resource Inventory and Monitoring Guideline*, NPS-75. When asked to define the driving force behind current I&M efforts, Williams quotes from the new *Guideline*: "Preserving the natural resources (and natural processes) in the National Parks may be the most important legacy the Park Service can provide American conservation."<sup>2</sup> In fact, a comprehensive NPS resource I&M program would be unique among such programs in the U.S. and throughout the world. Current programs outside NPS either monitor a wide variety of ecological parameters within small areas (as in experimental forests) or apply a narrow suite of measurements across large areas or networked sites for specific data needs (as in acid precipitation monitoring). The envisioned NPS program would apply a broad spectrum of ecological measurements to a large and diverse area. Moreover, information gleaned from I&M data would be valuable to many research programs that address issues within NPS and beyond, such as the Global Change Research Program. Successful development and administration of an I&M program of the magnitude presented here would provide a model for other agencies and institutions. In this way, NPS can seize the opportunity to be a national and global leader in I&M planning.

<sup>1</sup> Tradenames are used for information purposes only. No endorsement by the U.S. Department of the Interior is implied.

<sup>2</sup> *Natural Resources Inventory and Monitoring Guideline*, NPS-75.

Rugh is a technical writer and Peterson is a Research Biologist at the UWA CPSU, Seattle.

*The following publications are available from the Cooperative Park Studies Unit, AR-10, University of Washington, Seattle, WA 98195:*

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**Gravel aggradation and streambank erosion in a tributary to the Buffalo National River result from upland clearing and removal of riparian vegetation.**

riparian vegetation for agriculture have caused increased channel instability, anastomosing (dividing and reuniting), shallowing and widening (Jacobson and Pugh, 1992). As a result, there is evidence that significant changes are occurring in the physical habitats that influence aquatic ecosystems. This study uses a GIS to define the land use change in relation to slope in a portion of the Buffalo National River Basin and to interpret the potential for upland erosion and gravel transport.

#### The Watershed

Buffalo National River (BUFF) was established as the nation's first National River in 1972 for "preserving as a free-flowing stream an important segment of the Buffalo River in Arkansas . . ." (P.L. 92-237). In reality, BUFF is a narrow corridor straddling the river and averaging 2 miles in width. It comprises only 11 percent (95,730 acres) of the total watershed area (840,000 acres). The park is extremely susceptible to water resource degradation from external sources and lies downstream from all the diverse land use activities and pollution sources within the watershed.

As with many Ozark streams, the Buffalo River is in a state of disequilibrium. Because of its relatively steeper topography, greater magnitude of peak flood events, and gravel inputs from three different plateau systems, the Buffalo River may be among the most impacted streams from current and past land use changes. Gravel aggradation and clearing of riparian vegetation have resulted in widespread erosion affecting from 10 to 15 percent of the river corridor.

#### Methodology

The study unit encompasses 4,170 acres of private property in the Springfield Plateau region of the drainage basin. The area is sparsely populated and characterized by sharply defined valleys containing small streams separating flat topped ridges. Land use data from 1965, 1974, and 1979 were analyzed by Nyquist (1982), to an accuracy of 0.09 percent of the total acreage. The land use data for 1983 were digitized at the University of Central Arkansas (UCA) from aerial photography provided by the Arkansas Highway and Transportation Department. The slope characteristics were derived from elevation data digitized at UCA from USGS 7.5 minute quadrangle maps.

Studies by El-Swaify and others (1985), indicate

that on slopes greater than 7 degrees, overland flow is the major causal factor in the detachment of soil components. Clearing of forests and conversion to pasture greatly increase the overland flow component of a given precipitation event. A GIS analysis was employed, based on these physical processes, to determine the relative rate of conversion on 3 different slope regimes over 4 discrete time intervals.

#### Results

Nyquist (1982) studied the land use changes occurring in the entire Buffalo River watershed from 1965 to 1979 and determined that "the rate of conversion (from forest to agriculture) was nearly halved in the years 1974 - 1979." A summary of the data generated by this study is given in Table 1 and indicates the amount of cleared land increased by 126 percent from 1965 to 1983. Although this study corroborates Nyquist's findings of a decrease in the rate of conversion from 1974 to 1979 in the smaller study area, this appears to represent only a temporary slowdown in the conversion rate as opposed to any long-lasting trend.

As of 1965, 770 acres of the study area were in pasture, with 39 percent of this area on slopes greater than 7 degrees. An additional 962 acres had been cleared by 1983, with 50 percent of the conversion taking place on slopes greater than 7 degrees.

During the 18-year study period, the amount of land cleared for pasture on slopes less than 7 degrees increased by 103 percent, while conversion on slopes of greater than 7 degrees increased by 160 percent. Given the erodible characteristics of the areas being

cleared on the steeper slopes, plus the fact that these areas are being cleared at an increased rate, significant potential exists for further loading of gravel from highland areas and associated degradation of stream geomorphology.

The increased conversion on steeper slopes apparently results from several factors, among which are a lack of available level land and an upswing in the cattle market. While results of this analysis are not intended to be conclusive, due to the limited size of the study area, they are consistent with general field observations. Because of the importance of land use trends to BUFF's water resources, further research covering more of the watershed and using more current data is warranted.

*Stephenson is a geography student at UCA, Conway, Ark.; Mott is Hydrologist at Buffalo National River, Harrison, Ark.*

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**Poor soils and steep slopes combine to produce large volumes of gravel, which are transported by heavy rains to the surface hydrologic system at Buffalo River.**

**Table 1. Summary of land use and slope data.**

Time Period	Acres Converted			
	All Slopes	0 to 7 Degrees	7 to 14 Degrees	14 to 35 Degrees
1965	769	467	202	97
1965-1974	438	237	118	82
1974-1979	151	62	51	38
1979-1983	373	182	104	87
1965-1983	962	481	273	207

# Assessing Nonpoint Sources of Toxicity Part II: Using Biomonitoring Techniques

By Del Wayne Nimmo, John Karish, Heidi Bestgen, Trudy Steidl-Pulley,  
Mary Willox, Terri Craig, and Carla Castle

"What happens outside the parks dramatically affects what happens inside them." (Kerwin 1991).

Encroachment on our national parks by an "array of executioners: builders, commercial developers, recreation lovers, ranchers, miners, and thirsty, smoggy cities" (Kerwin 1991) is a common concern in all fields of resource management. Nowhere is this more obvious than in the field of water quality assessment. The complex problem of protecting water quality facing our nation today is especially felt in our national parks, where the goals are to maintain pristine conditions and the highest standards. As a result, most people visiting parks believe they have entered an isolated, uncontaminated "biosphere."

Unfortunately, this is not the case. What happens to water **before** it enters parks controls the quality of water **within**; parks are dependent upon this water regardless of where it comes from or its condition. The most insidious threat is from nonpoint source pollution (i.e. pollution neither enclosed in a pipe or conveyance nor subject to federal or state effluent limitations).

How to confront these nonpoint source issues seems to be the "\$64,000 question." The scientific complexity of the watershed, surface and subsurface geology, and the sociopolitical complexity of land use surrounding parks makes the protection of water quality a formidable task. It is even more difficult to address the interaction of individual pollutants with the physical characteristics (i.e., pH, dissolved oxygen) of natural waters. In an effort to address these complex concerns, we have developed and initiated various pilot biomonitoring programs (see *Park Science*, 12:3, pp. 26-28) in five national parks, each with differing nonpoint source water quality problems (Table 1).

The issues and questions affecting these parks present scientists and managers with various challenges for designing early-warning programs to detect, test, collect, analyze, and present the evidence for nonpoint source pollution. **Biomonitoring** assists in assessing nonpoint source pollution problems by: (1) helping to maintain objectivity when addressing water quality, (2) targeting and/or prioritizing suspected problems, (3) aiding in identifying and prioritizing future sampling sites, (4) identifying certain toxicants (when used in conjunction with chemical analysis) at a particular sampling location, and (5) helping, cost effectively, to discover and understand the causes of water quality impairments.

Biomonitoring is an objective way to address water quality issues. This was the case with the Namekagon River, St. Croix National Scenic Riverway (SACN), and an unnamed creek within the Ft. Darling Unit of the Richmond National Battlefield Park (RICH). At the Namekagon River, the test water looked "healthy" (clear, with vegetation and insect activity), but biomonitoring – using daphnids and fathead minnows – indicated that water quality problems existed. First, there were significant decreases in the reproduction of daphnids in waters coming from two of the three cranberry marshes (Sites 3 and 5, Fig. 1). Second, at Site 5, only 50 percent of the larval fathead minnows survived the 96-hour *in situ* exposure compared to 100 percent that survived at Site 6, which receives substantial dilution from a larger unimpacted tributary – Potato Creek. In contrast, at the Neimitz marsh (Sites 7, 8, and 9), daphnids reproduced better than average and the minnows survived at an average of 87 percent, giving no evidence of impact from the cranberry

marshes located there. Data gathered from these biomonitoring studies therefore, suggest that further investigation of Sites 4 and 5 is warranted.

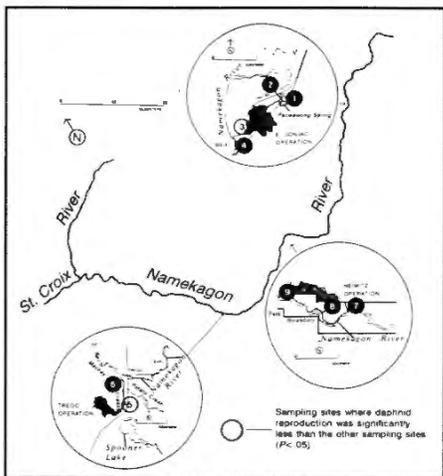
Biomonitoring assessment of an unsightly creek in the Ft. Darling Unit (RICH), also gave an objective indication of water quality. Here, unlike the Namekagon studies where all the water samples looked "healthy,"

extreme turbidity and an intense rust color from leachates seeping into the creek out of a nearby landfill obviously suggested impaired conditions. But biomonitoring indicated that substances in the leachates, contrary to assumptions, were not toxic to the daphnids, amphipods, or minnows in the initial tests or in chronic toxicity tests with daphnids in later studies (Fig. 2). Because of the results from these studies, we were able to conclude that the absence of aquatic life in the creek probably was due to thick, soft sediment-oxides and not, as first believed, to toxic chemicals from the landfill.

In addition to objectivity, biomonitoring can target and/or prioritize already suspected problem areas in parks. For instance, information gained in an Everglades NP (EVER) study, using daphnids, minnows, and feeding rates of amphipods, suggested that specific canals were impaired and should be selected for

Table 1. Locations where nonpoint, biomonitoring, pilot programs were conducted.

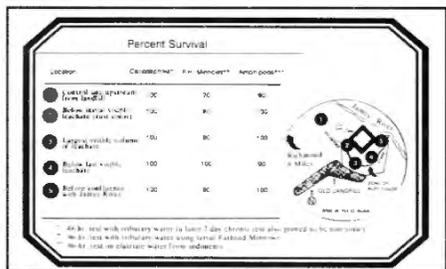
I. ST. CROIX NATIONAL SCENIC RIVERWAY (SACN)	
SITE:	The Namekagon River, a tributary to the St. Croix River, Hayward, Wisconsin.
ISSUE:	Nonpoint sources from extensive commercial cranberry marshes.
QUESTION:	Are pesticides and/or nutrients entering the Namekagon River?
II. RICHMOND NATIONAL BATTLEFIELD PARK (RICH)	
SITE:	The Fort Darling Unit near Richmond, Virginia.
ISSUE:	Nonpoint source from a landfill contained within the park.
QUESTION:	Are leachates from the landfill, which have severely discolored the sediments of an unnamed creek within the park, toxic to aquatic species?
III. EVERGLADES NATIONAL PARK (EVER)	
SITE:	Southern Florida.
ISSUE:	Nonpoint sources from encroaching agriculture and urbanization.
QUESTION:	Two problems currently being addressed are: (1) the high concentrations of mercury identified in both the bass and the endangered Florida Panther within the park (Simons 1991; Loftus 1990), and (2) the rapid die-off rate of the park's native vegetation (Robblee and DiDomenico 1991). How can the park incorporate biomonitoring to address these problems?
IV. UPPER DELAWARE SCENIC AND RECREATIONAL RIVER (UPDE)	
SITE:	Narrowsburg, New York.
ISSUE:	Nonpoint source from a nearby Superfund landfill.
QUESTION:	Are leachates from the landfill, which have been discoloring the river sediments, toxic to aquatic species?
V. WILSON'S CREEK NATIONAL BATTLEFIELD (WICR)	
SITE:	Near Springfield, Missouri.
ISSUE:	Nonpoint sources from increasing nearby urbanization.
QUESTION:	Is the rapid urbanization of Springfield affecting the quality of water in Wilson's Creek within the park?



**Figure 1.** Locations of cranberry marshes and bio-monitoring sites along the Namekagon River, St. Croix National Scenic Riverway, Wisconsin. Sites 1, 2, 6 and 7 are reference sites which were either above the influence of the cranberry operations or, as with site 6, greatly diluted by another tributary.

further in-depth studies. By ranking the three test endpoints (eating rate of amphipods, growth rate of larval fathead minnows, and reproduction rate of *Ceriodaphnia dubia*) and subdividing the ranks into good, fair, and poor (Fig. 3), an association between endpoint ranks and water quality was made 74 percent of the time. This led to prioritization of suspected problems and reevaluation of chosen controls.

Pineglades Lake, for example (Site 1, Fig. 3), because of its central location, isolation from direct surface water (canals) or groundwater, and history of good water quality, was initially considered as a control site



**Figure 2.** Percent survival of test species exposed to water and sediments from one control site upstream and four sample sites downstream from a landfill in a small unnamed creek, Richmond National Battlefield Park, Virginia.

for the studies; however, it ranked lower than expected. Thus, based on higher ranking, other lakes and canals in the park were targeted as more appropriate controls for future studies. Endpoint ranking also uncovered severely impacted water in need of high, immediate prioritization. Exposure to waters from canal sites L-28Tm and S-12C, endpoint ranked "poor," caused spinal deformation in a few of the larval fathead minnows tested - a condition seen only in severely impacted waters.

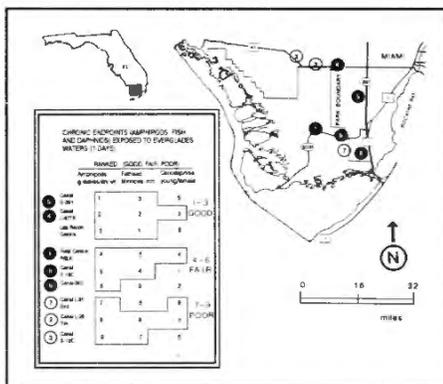
Using known test data, biomonitoring can aid in identifying and prioritizing toxic sampling sites for future biomonitoring studies. Eight samples of leachates entering the Upper Delaware Scenic and Recreational River (UPDE) from a nearby landfill were shipped to a cooperating laboratory. Toxicity was detected in five, three, and two samples using daphnids, larval fathead

minnows, and amphipods and grass seeds respectively. However, a question arose about many more seeps located upstream and downstream from the landfill that were not tested due to limitations of lab space, time, and money.

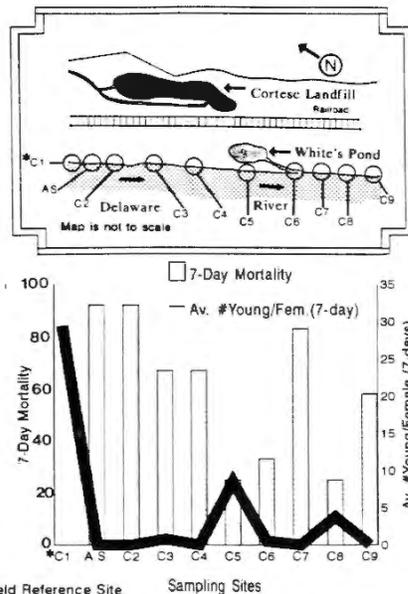
The question was, could we conduct biomonitoring tests and use the information to prioritize the leachate areas based on toxicity? Thus, a second series of tests was conducted on site with the daphnids; results indicated that all the leachates, except at field reference site C1 (surfacing upstream from the landfill at the river's edge), were acutely or chronically toxic to the daphnids (Fig. 4). Among the toxic sites identified were A.S., a spring with substantial flow, and C2, the most toxic seep, where 92 percent of the daphnids died within 12 hours. Another sample collected from C2 was shipped to a cooperating laboratory, where its toxicity to fish and grass seeds was identified. Additional chemical analysis of the C2 leachate detected the presence of acetone, methylene chloride, and ammonia.

Another important toxic site identified was C9, which because of its "healthy" color, was previously believed to be downstream from the leachate influence. Findings therefore indicated that (1) data from the onsite daphnid studies were useful in prioritizing the locations of leachates for more in-depth analysis, (2) assessments of toxicity should be made with a variety of test organisms, in this case daphnids, minnows, amphipods and grass seeds for a complete confirmation and understanding of the biological impact, and (3) without toxicity testing, a full comprehension of the toxicity of all the leachate sites would not have been disclosed, including C9, which at first had appeared to be unimpacted.

Living organisms can be used in conjunction with chemical analyses to identify certain toxicants affecting water quality at a particular sampling location. Earlier biomonitoring investigations of tributaries, springs, and segments of the Wilson's Creek watershed, conducted during two different seasons within two years at Wilson's Creek National Battlefield (Nimmo et al., 1992), suggested that water collected from Site 6, above the park, was toxic to daphnids each time tests were conducted (Fig. 5). Next, biomonitoring plus Toxicity Identification Evaluation (TIE) procedures were



**Figure 3.** Locations of biomonitoring sites in Everglades National Park, Florida. The insert shows the relative ranking (good, fair, poor) of those sites based on three chronic test endpoints (feeding rate of amphipods, growth rate of larval Fathead Minnows, and reproduction rate of *Ceriodaphnia dubia*). Blocks represent endpoint agreement among the three categories. Closed circles represent those sites that ranked in the "good" or "fair" categories whereas sites ranked in the "poor" category are shown as open circles.

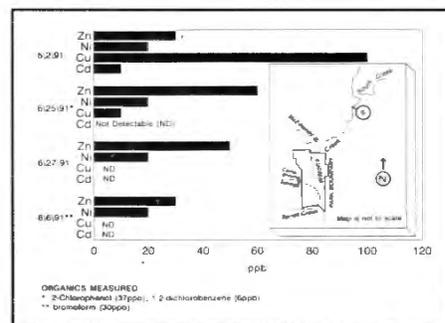


**Figure 4.** Biomonitoring sample sites of leachates entering the Delaware River (Upper Delaware Scenic and Recreational River, New York) below a Superfund landfill. Data shown in the bar graph represent the 7-day mortality of the test species, *Ceriodaphnia dubia*, and the line graph represents the average number of young produced per female *dubia* that survived the exposure after 7 days.

planned. These procedures join biomonitoring with lab tests to identify the physical and chemical characteristics of the substances believed to be toxic. Eventually, after biomonitoring and TIEs were conducted, the appropriate analytical techniques were chosen to verify the toxicant(s) responsible for the toxicity. The data gained from Site 6 indicated that when metals (copper, nickel, and zinc) were present at specific concentrations, the result was toxicity (Fig. 5).

We believe biomonitoring to be a cost-effective approach for discovering and understanding the causes of water quality impairments. The data gathered at both RICH and UPDE were multi-year research efforts designed to develop and test procedures under field conditions. After the procedures were established and used in SACN, EVER, and WICR, we approximated

**Continued on page 8**



**Figure 5.** Location of biomonitoring site 6 with respect to Wilson's Creek National Battlefield Park, Missouri. In previous studies, site 6 was chronically toxic to daphnids. By using Toxicity Identification Evaluation (TIE) procedures, combinations of zinc (Zn), nickel (Ni), and copper (Cu) were judged to be responsible for the toxicity.

# Water Rights and the National Park Service

## Part II: The Federal Reserved Water Rights Doctrine

By Owen Williams

**Editor's Note:** This is the second of two articles by the Chief, Water Rights Branch, NPS Water Resources Division in Fort Collins, CO. The first appeared on p. 30 of *Park Science*, Vol. 12 No. 3.

### Origin

The tension between the Doctrine of Prior Appropriation and federal "Reservations" culminated in a court case that changed the face of western water law. The Fort Belknap Indian Reservation in Montana was created in 1888 to change the "habits" of "... a nomadic and uncivilized people" into those of "... a pastoral and civilized people." In 1898, efforts to develop irrigated agriculture on the reservation immediately ran afoul of the Doctrine of Prior Appropriation because water in the Milk River had been appropriated prior to 1898 by other irrigators. Thus, under state law, the Indian appropriation would be junior, and unfulfilled.

In 1908, the U.S. Supreme Court determined that when Congress created the Indian Reservation, by **implication** it also reserved from the unappropriated waters of the state that water necessary to achieve the intent of the reservation – namely, irrigated agriculture. This reservation of water occurred on the date of the

land reservation and was senior to appropriations that occurred after that date.

This case, *Winters v. United States*, 207 U.S. 564, 28 S.Ct. 207, 50 L.Ed. 340 (1908), created what came to be known as the Winters Doctrine or Winters Right. While the decision stood the Doctrine of Prior Appropriation on its head, it at least appeared to be limited to the unique concerns of Indian law.

### Evolution

The fervent hope of westerners that the Winters Doctrine would apply only to Indians was soon dashed as the Court generalized its applicability to all "federal enclaves." Over time a series of decisions by the U.S. Supreme Court gave the doctrine substance and form. Eventually this creation of the court took on its present name and, through recent decisions, its growth finally was checked.

Some have argued that the doctrine was merely a ploy to legalize a federal "taking of property without due compensation." Others hold that the doctrine represents state law giving way to Federal Sovereignty. Whichever the case, federal reserved water rights added substantial uncertainty to what had been viewed as a fairly ordered and settled approach for using a scarce resource.

### Elements of the Doctrine

As the Court has made rulings, it has "interpreted" its own creation. Subject to future additional evolution, the doctrine has the following characteristics:

- when land is set aside from the Public Domain for a specific purpose requiring water, water sufficient to accomplish that purpose is reserved from the unappropriated waters of the state;
- the priority date of the right is the date of the land reservation;
- the amount of water reserved is that **minimum** amount necessary to **prevent the defeat** of the purpose of the reservation;
- the reservation of water is only for the **primary** purpose of the reservation, no other;
- the right is not constrained by state law (for example, it is not lost due to non-use, and purposes need not be recognized as beneficial by the state); and
- the right is to meet present and **future** needs.

### How the Doctrines Relate to the NPS

#### NPS Reservations

As noted earlier, the NPS organic act defines its "reservations" and their purposes. It would appear that the NPS's position would be pretty secure and therefore eliminate any concerns about water rights. The reality of the situation however is a bit more complicated. First, the reserved rights doctrine may not apply to all NPS areas because some have not come from the Public Domain, but rather from state or private ownership.

Furthermore, many NPS reservations are of fairly recent vintage. Thus, while the doctrine might apply, the priority date may be so junior as to be ineffective in providing protection against impact from other water users.

#### The NPS Case

Additional complications are found in the definition of NPS reservation purposes. While the NPS organic act links Parks, Monuments and other units under the

same umbrella of purposes, some State Courts have made a distinction between Parks and Monuments. Specifically, the courts have looked to the enabling legislation or Proclamations for Monuments to find purposes rather than relying upon the broad language quoted above. Contrary to expectation, looking at the authorities for setting aside specific sites does not necessarily produce a better definition of purposes.

The determination of the minimum amount of the right is a further complication, especially in view of the vague purposes often cited in typical enabling legislation or Proclamations. As a general principle, the courts are reluctant to accept the proposition that a Park or a Monument has a reserved right entitlement to all water not appropriated at the time of the reservation's creation, including natural stream flow. This should not be surprising considering the potential for impacts to long standing state water rights. Senior appropriators could suddenly find themselves to be juniors because of the federal reserved right.

#### Limitations of the Doctrine

The only way to quantify and secure recognition of a federal reserved water right is by participating in a basin-wide general adjudication of water rights. This was made possible in 1952 by passage of the McCarran Amendment (66 Stat. 560, 43 U.S.C.A. S 666) which granted a limited waiver of Sovereign Immunity to allow suit of the United States for the purpose of adjudicating water rights. Thus it is that, to secure its rights to water in Parks and Monuments, the NPS must develop evidence designed to convince the court that (1) the U.S. is **entitled** to water (water necessary for the purpose of the reservation), and (2) the amount claimed is the **minimum amount** necessary to prevent **defeat** of the reservation purpose.

Generally, when the NPS enters State Court, often a less than sympathetic arena, it must be prepared to bear the burden of proof and demonstrate with a preponderance of evidence that its claim to water for each and all reservation purposes is valid and the minimum amount necessary for both the present and the future. When the court has ruled and, if appropriate, all appeals have been exhausted, the NPS must "live" with the determination. If quantities granted prove inadequate, the only recourse is new appropriation or acquisition of existing rights under state law.

#### What the NPS Faces Now and in the Future

Drought and municipal growth are two of the many water related challenges facing the NPS. Water shortage coupled with increased demand result in increased pressure to dam rivers and pump aquifers. When these things occur near NPS units, it is very likely that NPS resources sooner or later will suffer. Surprisingly, perhaps, one line of defense lies in water rights. In certain instances the NPS can assert its water rights seniority as basis for protection from injury by junior appropriators. However this very likely will result in litigation, even adjudication, requiring substantial commitments in time and money by all water users, especially the NPS.

As municipal and other kinds of development proceed, most western states feel a pressing need to eliminate the uncertainty attendant to un-adjudicated, and therefore un-quantified, federal reserved water rights. As a result, the states have by and large com-

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## Biomonitoring Techniques

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the average cost of each of the studies (12 sampling sites tested over 7 sampling days) to be only \$3,000 for 3 weeks of effort. This is a modest amount compared to only one priority pollutant (chemical by chemical) analysis (one sampling site tested one time, including both organic and inorganic compounds), which can cost between \$1,500 and \$2,000.

Water and its accompanying aquatic communities are critical to all forms of life. We believe the data gathered from our pilot programs indicate that biomonitoring can directly assess the health of aquatic and terrestrial life. Biomonitoring is needed to ensure these aquatic resources for various interests if only for the aesthetic value of a spectacular waterfall. Increasing human populations and expanding land-use needs require society to research and develop new ways of understanding and detecting the subtle or perhaps not-so-subtle changes in water quality in our parks from outside sources. Biomonitoring, because it has proven to be objective as a way to target and prioritize suspected and known problem areas, in conjunction with TIE to identify specific toxicants, is worth pursuing as a valuable, cost effective component of monitoring programs in our national parks.

*Nimmo is an aquatic toxicologist and Wilcox is an associate, both with the NPS Water Quality Division in Fort Collins, CO; Karish is Chief Scientist of the NPS Mid-Atlantic Region; Bestgen, Steidl-Pulley, Craig, and Castle all were graduate students at CO State U at the time of this study.*

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# Hemlock Woolly Adelgid Threatens Eastern Hemlock in Shenandoah National Park

By J. Keith Watson, Entomologist

In the winter of 1988-1989, Shenandoah National Park (SNP) personnel observed many dead Eastern hemlock, *Tsuga canadensis* (L.) Carriere, in Thornton and Frazier Hollows of the North District. Later investigations conducted in the winter of 1990 detected many defoliated hemlocks while many others had partial foliage loss and exhibited chlorosis. Several dozens of trees in both hollows were affected to varying degrees and many trees estimated to be approximately 200 years old were dead. Close examination of the foliage revealed the presence of woolly masses at the base of the needles and twigs (Fig. 1). Each woolly mass enclosed a small soft-bodied rounded aphid-like insect suspected to be, and later identified as, the hemlock woolly adelgid, *Adelges tsugae* (Annand)(hereafter referred to as HWA).

Entomologists believe this species was introduced from eastern Asia where they have found endemic, innocuous populations of this adelgid infesting Asian hemlock species in Formosa and Japan (Takahashi 1937, McClure 1987). This insect was first reported by P.N. Annand (1928) to infest *T. heterophylla* Sargent in the Pacific Northwest of the United States. The first detection in the East was recorded from Richmond, VA in 1953 (Anhold 1990), but the exact time of the adelgids introduction into the United States remains unknown. From these suspected entry points in the United States, the range of the insect has gradually spread and in many parts of its



Figure 1. Egg masses produced by overwintering adults (Used by permission of Mark McClure).

range has caused extensive mortality of both ornamental and forest hemlocks (McClure 1987). Range extension has occurred through diverse mechanisms and McClure (1990) provided data that showed wind, birds, deer, and human activity were primary factors in HWA dispersal.

The HWA is a sap-sucking insect of the Order Homoptera, family Adelgidae, closely related to aphids, whiteflies, and scales. Adelgids are typically a two host species, with spruce (*Picea* spp.) species being the primary hosts. However, no native *Picea* have been shown to support the HWA. Twelve *Picea* spp. were tested (six native and six non-native) by McClure (1989) for adelgid suitability and none were able to sustain reproductive populations. The complex life cycle of the HWA makes management difficult, but allows several opportunities to direct management tactics. Life history of the HWA can be obtained from McClure (1989) and is summarized in Figure 2.

The adelgid extracts fluids from the tissues of the inner bark or phloem by inserting its stylet-like mouthparts through the outer bark of small twigs and branches. Damage to the host occurs as a result of stress induced when heavy infestations withdraw large

amounts of life sustaining fluids from the tree. Additionally, some scientists believe that a toxic saliva is injected into the tree during feeding that disrupts plant growth hormones and modifies vascular tissues in the tree (Puritch and Petty 1971). However, this mechanism has not been documented with the HWA. Still, the trees lose vigor and become susceptible to additional and often more damaging stresses, especially drought, hemlock borer (*Melanophila fulvoguttata* Harris; Coleoptera: Buprestidae), and Armillaria root rot, *Armillaria mellea* (Vahl ex Fr.) Karst.

Dr. Mark McClure, HWA authority at the Connecticut Agricultural Experiment Station, believes that heavy infestations alone can cause hemlock mortality. He also reported on the stand and tree condition of forest hemlocks in Connecticut and discovered that when healthy vigorously growing uninfested trees became infested with HWA, they declined gradually and all were dead within four years (McClure 1991). Heavy HWA populations along with other stress factors could contribute to the death of infested hemlocks in SNP.

In SNP, the HWA has been found in all districts, elevations, and aspects in 88 percent (n = 49) of the surveyed hemlock stands. Mortality has become widespread throughout the park and little can be done to prevent the continued spread and impact of the HWA. Data collected in February 1992 from Frazier Hollow indicated a 100 percent decline in the number of hemlock crowns that received a healthy rating (Class 1) in July 1990. Furthermore, the number of hemlocks with lower crown ratings (Class 2 and 3) increased 178 and 1400 percent respectively. The number of adelgid related deaths (Class 4) increased 100 percent (Fig. 3). Although this evaluation was based on a small sample size, the condition of the hemlock stands in the park is similar to Frazier Hollow. Data to evaluate stand condition and mortality rates are presently being collected parkwide. Presently, about 10% of the hemlocks in Thornton and Frazier Hollows are dead due to stresses associated with HWA. Considering the degree of infestation and additional stresses in SNP, a large number of Eastern hemlocks could be lost. If the prognosis is severe as McClure hypothesizes all hemlocks may be in jeopardy of being lost.

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## Water Rights

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mitted to adjudicating all water rights by the close of this century. Preparing for the court battles that inevitably await will require herculean efforts by the NPS and other federal agencies.

### Conclusion

The legal doctrine that governs most water use in the west conflicts with the "fundamental purpose" of the NPS. This doctrine arose, in the absence of federal guidance, to meet the needs of commerce in a semi-arid setting at a time of rapid and almost chaotic development. It served its intended purpose well, but it did not provide for the unanticipated needs of a growing and increasingly sophisticated nation. The requirements of legislation and Proclamation created conflicts that culminated in a retrofit of the doctrine using Court-created "implied rights."

The NPS employs both the Federal Reserved Water Rights Doctrine and the Doctrine of Prior Appropriation to accomplish its mission. The process of securing and protecting water rights is demanding, requiring in-depth scientific investigations and complex legal argument. However, even though the investment to protect water rights may be high, the cost of not protecting them likely would be higher. This becomes ever more apparent as water development and municipal growth place increasing demands upon the same water sources as are relied upon by the fragile ecosystems of Parks, Monuments, and other NPS units.

The opinions expressed are those of the author and do not necessarily reflect those of the Department of the Interior or the National Park Service.

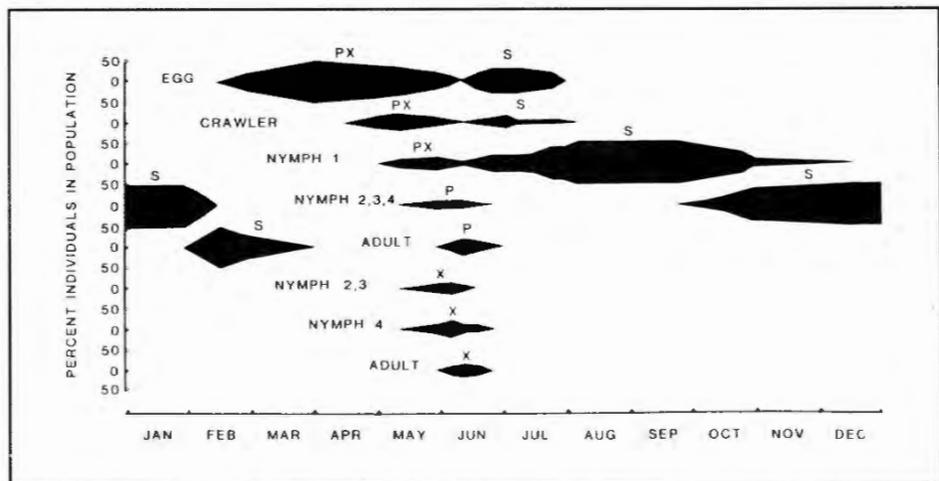


Figure 2. Seasonal life cycle of the HWA. S = wingless overwintering generation; P = wingless forms of spring generation; X = winged migratory forms of spring generation (Used by permission of Mark McClure).

# Woolly Adelgid Threatens Shenandoah Hemlock

Continued from page 9

In SNP, the hemlock mortality associated with HWA was apparently initiated by drought induced stresses during 1986-1988. The combined stresses of drought and HWA infestation attracted the hemlock borer, a cambium feeding beetle, which girdled and ultimately killed many of the hemlocks. Evidence of secondary beetle invasion was indicated by the presence of emergence holes and the outer bark being flaked from the tree by woodpeckers probing for borer larvae, revealing the deep rust color of the inner bark. Hemlock mortality caused by the secondary invasion of the hemlock borer has been a well documented phenomena (MacAloney 1967). However, several dead hemlocks in SNP did not show evidence of attack by the hemlock borer, suggesting death occurred from drought and adelgid infestation, and possibly *Armillaria* root rot. Additional stresses from gypsy moth defoliation and acid deposition may have contributed to the hemlock decline.

The potential impact of hemlock decline and mortality on park resources has resource specialists concerned. Obviously, natural resource components and biotic associations in hemlock ecosystems will be greatly affected. The adelgid has been observed in two high resource value areas in the SNP. One of these is the Limberlost, a 100 acre natural area that contains many virgin Eastern hemlocks saved from the logging industry by George Freeman Pollock. Some trees in this stand are estimated to be near 400 years old. The other unique area where hemlock decline is evident is Camp Hoover, a former retreat for government officials, and a valuable cultural and natural area. President Herbert Hoover established this fishing camp on the Rapidan River and later donated the property to the SNP.

## Effects of Control Agents

Though a significant threat to the Eastern hemlock forest exists, it is doubtful that HWA management in a forested ecosystem would be successful although it could be possible in isolated "urbanized" settings in developed zones. Selected individual trees must be saturated with suppression agents from ground based equipment to ensure a high percentage of adelgids are contacted by the treatment. This quickly becomes very expensive, labor intensive, and time consuming.

"Safe" control agents could be used with this method, but they are economically unfeasible and environmentally untested to be effective in long term adelgid management. Injection of pesticides into the cambium where translocation of the pesticide would reach the adelgids is another possibility. Other traditional chemicals proven effective for adelgid control exhibit wide spectrum toxicity to other "non-target" organisms and are unacceptable for use in national park ecosystems. Natural parasitoid and predator complexes are poorly known and their potential as control agents is uncertain.

Programs to monitor populations of the adelgid in SNP and elsewhere should be developed to obtain information on the impacts of this potentially damaging insect. Monitoring is extremely important because populations of this insect can build rapidly on hemlock due to 1) parthenogenesis - the female's ability to produce offspring without the existence of the male, 2) the adaptation of two successful reproducing generations per year, 3) few significant natural enemies, and 4) other prevalent stresses in the SNP ecosystem.

## Monitoring Plans

Monitoring the HWA can be incorporated into the

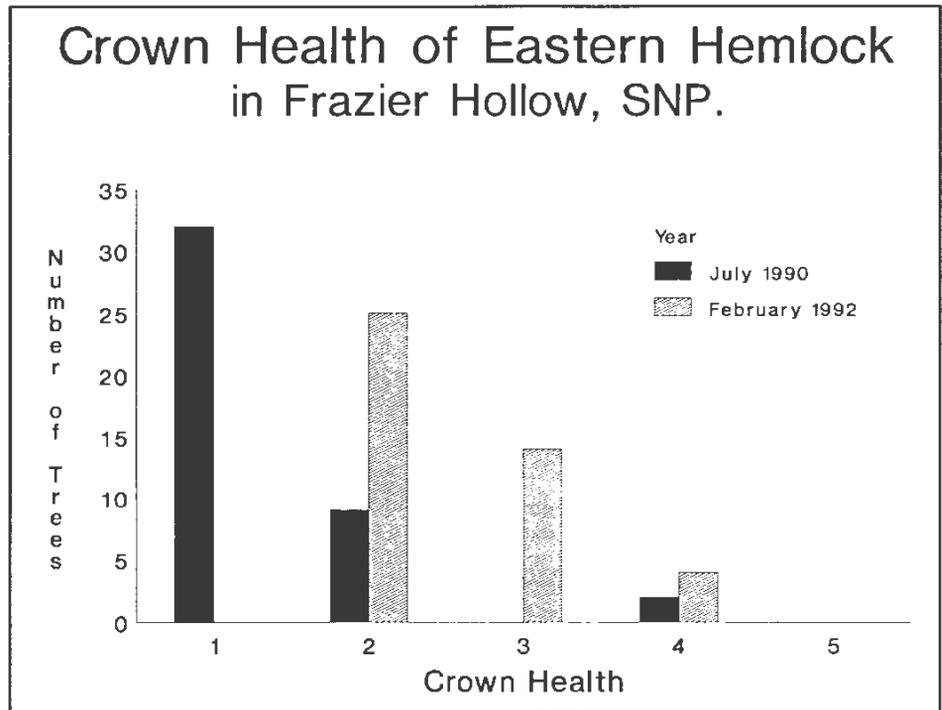


Figure 3. Crown Health of Eastern Hemlock in Frazier Hollow, SNP.

current inventory and monitoring system established at SNP with only minor modifications to the existing hemlock component protocols. At present, existing plots have been surveyed and 80 percent have HWA infestations. These plots will be monitored for adelgid impacts as well as the standard measurements detailed in the Long-Term Ecological Monitoring System LTEMs manual (Smith and Torbert 1990). Additionally, plots will be established, inventoried, and monitored in uninfested hemlock stands. Data collection will allow resource specialists to detect initial invasion and monitor the spread and effects of the HWA in hemlock stands throughout SNP.

## Other Affected Areas

Any NPS units in the eastern United States with a hemlock forest component could potentially be affected by infestations of the HWA. Large stands exist in both the Great Smoky Mountains NP (GRSM), Shenandoah NP, Catoctin Mountain Park (CMP), and Delaware Water Gap National Recreation Area (DEWA). No infestations have been detected in the GRSM (Langdon, personal communication) but many virgin hemlock stands remain that provide both high value aesthetic and ecological resources. Hemlocks forests in DEWA provide one of the area's most valuable visitor use resources and recently have become infested. The infestation is rapidly increasing, causing widespread defoliation that represents a tremendous potential for significant hemlock mortality in the future (Millington, personal communication). Blue Ridge Parkway personnel have reported the HWA at various locations from the northern sections south to Milepost 150 (Teague, personal communication).

Other infestations have been reported in the National Capitol Region where some pesticide treatment has occurred. No other infestations have been reported, but surveys should be conducted to determine the presence of this non-native species in our federal

lands, particularly the National Park System, where a major goal is the preservation of natural ecosystems and processes. If infestations are suspected, samples should be collected and sent to local universities or specialists to confirm identifications. Infestations should be reported to the Regional USDA Forest Service Pest Management Office.

The adelgid has been in SNP for many years, and extensive mortality can be expected, especially when associated with other stress factors. The outlook for the hemlock stands in the park remains unclear due to the uncertainty that surrounds the adelgids true potential as a contributor to hemlock mortality. What is certain is that the HWA will remain in Shenandoah as long as the hemlocks remain. When the hemlocks become sparse, the complex community of organisms associated with this forest system also change. Extensive efforts should be initiated to develop better management strategies and an understanding of HWA and its role in forest dynamics. It is imperative that efforts be conducted to inventory and monitor our hemlock forests so better assessments can be made toward determining the potential this species has on an extremely valuable natural resource community.

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# Eastern Hemlock: The Next American Chestnut?

By David Hayes

Most of us are too young to have any memory of the American chestnut (*Castanea dentata*) as a significant component of eastern forests. Once comprising 25 percent of total timber volume, it is now relegated to persistent stump sprouts that survive for a few years before succumbing to the cause of its decline, the introduced chestnut blight fungus (*Endothia parasitica*). A similar fate may await the eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*Tsuga caroliniana*) at the hands of yet another Asian invader: the hemlock wooly adelgid.

Hemlock wooly adelgid (*Adelges tsugae*) has no known predators or parasites. Within one to four years, most untreated hemlocks are dead. Highly desiccated, the dead trees break apart very rapidly; whole stands have been levelled in Connecticut in just a few years. Since the moisture content of hemlocks that have succumbed to the adelgid is greatly reduced, fire danger is intensified.

The most troubling aspect of this situation is the potential for large-scale loss of hemlocks from eastern forests. In southeastern New York and most of Connecticut this has already begun. *Tsuga canadensis* is often found in great numbers here, sometimes at canopy densities of 80 percent or higher. It is extremely shade-tolerant, and can persist as an understory species for decades; its longevity also allows it to reach the overstory when conditions permit. The shading it provides results in reduced sunlight transmission through the canopy, hence lower temperatures in streams, wetlands, and on the forest floor. It provides roosting sites for woodland birds, including barred owl (*Strix varia*), great horned owl (*Bubo virginianus*), and ruffed grouse (*Bonasa umbellus*).

Since there is no apparent ecological replacement for hemlock, its loss on a large scale will be significant. The cool, moist microhabitats it provides will be greatly reduced. The simultaneous loss of hemlocks growing in dense stands on steep ravine slopes will undoubtedly cause erosion. There is no practical way to control *A. tsugae* in areas not accessible to large hydraulic spray equipment; aerial applications are ineffective since 100 percent foliar coverage cannot be attained.

## Wooly Adelgid

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Most of the trees in this hemlock-dominated forest at Vanderbilt Mansion NHS are in their first year of infestation. (Photo by D. Hayes)

The northern front of the infestation is moving through New York State and New England. The Roosevelt-Vanderbilt National Historic Sites are near the current northern frontier of the adelgid's spread. *A. tsugae* has invaded the landscaped area at Vanderbilt Mansion NHS, and is being treated with horticultural oil. Landscaped areas in all units of the park, which total 48 ha (119 ac), will be rigorously monitored, and all infested trees will be treated. In the natural forest zones of the park (170 ha = 420 ac), permanent monitoring stations are being established to track changes in species composition of plants, invertebrates, herpetofauna, and birds. Streams and wetlands will also be monitored for changes in physical and chemical characteristics.

While these efforts will add to our understanding of the effects of hemlock population decline or local extirpation, they will be poor consolation for the loss of such an important species from forest ecosystems in the eastern U.S.

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Horticultural and resource management personnel from Roosevelt-Vanderbilt NHS attended an April 29, 1992 meeting at Mystery Point in Garrison NY, where site managers, foresters, landscapers, and researchers discussed strategies for dealing with *A. tsugae*. Mystery Point, a 19th Century estate now owned by the environmental organization Scenic Hudson, provided a dramatic setting, with dead and dying eastern hemlocks covering much of the estate's 136 acres.

Mark McClure of the Connecticut Agricultural Experiment Station briefed attendees on adelgid identification, life cycle, and control techniques. Dr. McClure left soon after an a two-month research trip to Japan, seeking natural predators of *A. tsugae* for potential introduction in the U.S.

Hayes is *Natural Resource Specialist at Roosevelt-Vanderbilt NHS.*

## book review

**WILDLIFE RESEARCH AND MANAGEMENT IN THE NATIONAL PARKS**, R. Gerald Wright, 1992. University of Illinois Press, Urbana and Chicago, 224 pages. Cloth, \$32.50. Notes, appendix, figures, tables, bibliography, and index.

Gerry Wright has presented a much needed and long overdue account of the evolution and present day treatment of wildlife research and management in the National Park Service. From the introduction to its conclusion, relatively unusual facts and little known accounts of past actions and deeds are presented. Unpublished literature and incidents that may have long escaped attention, have been forgotten, or have been buried, are here made available. Memories and notes of those managers, biologists, and scientists who have left the Service in body but not in mind are now brought into the light. As Paul Harvey says, "And now, the rest of the story."

Gerry's unique perspective is not only informational and thought provoking, it reflects his personal concerns and commitment for wildlife management and research in the Park Service. While some may argue that he is not critical enough, others will maintain that the book is an expression of sour grapes. It is neither. It is a well written and researched review of the history and evolution of wildlife management and research in the NPS.

The book is an important and valuable contribution to an understanding of the evaluation of NPS wildlife research and management activities ... a must read for everyone who is involved, interested, or concerned with wildlife in our national parks. It is not only for those within the Service, but for those in conservation at the local, state, and federal levels and in the private sector.

While the book is not perfect, the errors are few, the generalizations, data interpretation, and interpretation of past and present literature are neither slanted nor biased pro or con. The availability and use of more current data and information in a number of the tables and figures would greatly have enhanced the book. Read it; you'll enjoy it.

Michael A. Coffey, *Wildlife Biologist,  
Science Branch  
NPS Wildlife and Vegetation Division  
Washington, DC 20013*

# notes from abroad

By Janet Edwards

Former Natural Resource Specialist  
Pacific Northwest Region

In 1909 Sweden passed legislation establishing its first nine national parks. They were intended to be undisturbed natural settings managed in similar fashion to USA national parks. Despite the fact that both park agencies deem one of their fundamental purposes as scientific, science in the parks means something quite different in Sweden than it does in the United States.

Abisko NP, situated adjacent to Lake Tome, is an international biosphere reserve. Here, within a nature reserve adjacent to the park, lies Abisko Research Station, established in 1903. Since 1935 it has been administered by the Royal Swedish Academy of Sciences. Hosting often as many as 80 scientists in the summer, it has become an internationally known Arctic research station, where investigations from many disciplines – especially bioscience and geoscience – are conducted. The commonest research topics are plant ecology and meteorology (Sonesson 1991). Equipped with workrooms, geo- and radio-laboratories, computer and drawing rooms, and greenhouse facilities, the station is open to visiting scientists (Royal Swedish Academy of Sciences 1985).

Abisko is only one of the many sites where environmental research is conducted in Sweden. Research within parks has not for the most part been driven by park administrators. Decisions about types and scope of research within parks have been generated by the investigating official, often from one of the Swedish universities, sometimes even from abroad.

By 1990 the Swedish Environmental Protection Board, under whose jurisdiction the national parks fall, realized the need for a systematic inquiry into the types of research that have been conducted in the parks. All published materials now are being collected and accounted for, their scientific integrity evaluated, and research methods assessed. Results will be noted and a corresponding data base will be created. In addition, both a geomorphological and a vegetation map are desired for each park. The "Documentation of Sweden's national parks," a report proposed by the national park administrative staff, will include baseline information on geology, flora, fauna, and other resources within specific parks (Bergqvist, 1990).

The 1983 (and most recent) literature collection for studies done within the parks has several hundred project entries including topics in geology, glaciology, meteorology, botany, zoology, limnology, ornithology, and entomology (Naturvardsverket 1983). Most of the projects are pure science based, as opposed to applied science or resource management oriented. Much of the research has provided important baseline data on park resources. The limitations of current and past research rest with the absence of projects that define resource problems and their proposed solution.

In an attempt to integrate and direct science in the parks, a research plan for the parks is being funded by the Environmental Protection Board. Written by university staff, this plan will describe proposed research needed to provide further information on park resources.

Despite the Environmental Board's interest in systematizing research in parks, most environmental

work done in Sweden is not earmarked for park sites. To understand why this is so, it is important to note three conditions that exist in Sweden and reduce the need for establishing large research project within parks.

First, Sweden has a long tradition of "every man's right" when it comes to land (Naturvardsverket 1982). Because of this, research sites can be set up as easily on private and company lands as on government owned lands.

Secondly, Sweden has a population of only about 8.3 million. For a country of 450,000 square km, about the size of California, Sweden is rather sparsely populated. In the far north, populations can be as low as 2 to 3 persons per square km. When seeking a naturally vegetated landscape where sites could be stationed, a researcher has a wide range of choices.

A third consideration is that Sweden's goals for nature protection include maintenance of landscapes sculptured by human use. Farmlands, pasture lands, burial mounds, and Laplander reindeer grazing traditions are as important as wilderness where protection is concerned. Human impacts on landscape are not always considered a negative attribute. Although uses are limited and often regulated, the general focus of nature research is not on monitoring normal and anticipated human impacts to the land. The major threat to natural resources generally is stated to be the forestry and agricultural industries. Where these activities prevail, there is direct and significant impact on biotypes (Larsson 1990, p. 8).

Although there currently is no integrated research program for parks, a large and cohesive environmental research effort has been pulsing in Sweden since 1967. At that time, one of the most comprehensive environmental programs, monitoring and assessing the effects of acid rain deposition, began. The national government reacted immediately to scientific findings about adverse impacts of acid rain. Rather than waiting for large funding or national guidelines, monitoring began shortly after the problem was first discovered in the late 1960s.

Swedish scientists are particularly interested in the critical load concept, hoping to discover how much pollution the environment can tolerate. With 80 to 90 percent of acid deposition coming from other countries, the need to investigate this building problem has pushed research on it to the fore. Liming of lakes is a common procedure, used to rehabilitate the affected aquatic environment. However, liming does not take place in national parks, since national standards require that parks be kept in their natural condition and maintained as baseline reference areas (Thornelof 1991). Thus the parks suffer greater cumulative impacts.

Global warming studies also are important in Sweden, although funded to a tune of only about one sixth the amount of the acid rain program. Sweden relies a great deal on data supplied by other countries. Some modeling work has been done on the probable species composition of Swedish forests after increased global warming. Changes in the patterns of mountain birch and incidents of insect defoliation also have been investigated. Cooperative research for global warming is ongoing, even on Svalbard Island north of Norway.

Outstanding wetlands, botanical resources, wildlife, and geological formations are as important as parks to Sweden's concept of nature protection. To-

gether the parks and reserves protect approximately 5 percent of Sweden's land base. The current parks comprise about 627,000 ha as compared with nearly 2 million ha of nature properties.

The National Environmental Protection Board has primary jurisdiction over environmental programs throughout the country, whether within parks, reserves, or other public or privately owned lands. The Board provides funds for such programs, then distributes them to local county boards (24 of them) for local research and monitoring. Requests can be made by the local county boards for establishment of new nature reserves and subsequent funding for inventory and management. Furthermore, science stipendiums are awarded yearly by the National Board for research as well as applied projects that enhance nature conservation efforts.

This year, management of the Swedish national parks was transferred from the National Environmental Protection Board to local county environmental agencies. The local offices are staffed with science professionals. Together they handle a variety of resource management projects for parks, reserves, bird sanctuaries, and other protected natural sites. County personnel grant and regulate permits for research on these sites. In addition, these environmental offices work with landowners as well as with the forestry agency, writing up agreements, discussing use restrictions, and designing rehab projects.

The holistic approach to science related to nature conservation in Sweden functions well for a country of its size and population. Visitor numbers are relatively low in parks, which means that most internal resource problems are incurred through permitted land uses. External threats, however, have been measured and are of immediate concern to Swedish environmental managers. To pinpoint impacts, baseline data gathered over an extended time, are critical to Sweden's approach to science. International conferences, agreements, and shared research also are important ingredients used to address protection of natural resources.

*Edwards has been living in Sweden and learning about its national parks and reserves for the past two years.*

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# information crossfile

Two NPS scientists, D.J. Shaver of Padre Island National Seashore and M.R. Fletcher of the CPSU at the University of New Mexico, appear in the Letters column of *Science* for July 24, 1992, with a spirited reply to Gary Taubes' article about Kemp's ridley sea turtle conservation (Research News, May 1, p. 614, *Science*). After correcting what Shaver and Fletcher term "ambiguous, misleading, or incorrect" statements regarding NPS activities in the Taubes article ("A dubious battle to save the Kemp's ridley sea turtle"), the authors note that "public awareness about the plight of sea turtles has increased as a result of NPS efforts." Further, they point out that "some of the biological information collected by the NPS was the first of its kind for the species and has been used to assist with efforts in Rancho Nuevo, Mexico" (where the turtles' eggs were collected each summer from 1978 to 1988 and transported to Padre Island National Seashore in an international multi-agency effort to establish a secondary breeding colony through imprinting.)

This saga has received ongoing coverage in *Park Science*, most recently in this issue (see pp. 26-27). The Shaver/Fletcher closes with this paragraph:

"The NPS is now focusing conservation efforts for this species on attempts to locate and protect nesting females (wild and headstarted) and stranded hatchlings. Staff at PAIS (Padre Island) are conducting extensive beach patrol and public education efforts, both of which have been given high priority in the recently completed Kemp's Ridley Sea Turtle Recovery Plan. As directed by the recovery plan, NPS mandates, and the Endangered Species Act, these efforts will continue for the foreseeable future."

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"Keeping aliens out of paradise," by Anna Maria Gillis in the July/August issue of *BioScience* (pp 482-485), describes the host of educational, research, and enforcement programs developed by the Hawaii Dept. of Agriculture, federal agencies, and numerous environmental groups in the effort to limit alien species' impacts on the native flora and fauna.

Gillis quotes Alan Holt, one of the authors of "The Alien Pest Species Invasion in Hawaii: Background Study and Recommendations for Interagency Planning" (prepared by The Nature Conservancy of Hawaii and the Natural Resources Defense Council) as suggesting that the rate of new species invasions is "thousands of times faster than it was in prehuman times, when one new colonist was estimated to arrive on the islands approximately every 10,000 years." Many scientists now say, writes Gillis, "that Hawaii harbors more aliens than natives." She discusses biocontrol and notes the objections of British Museum entomologist Frank Howarth. He attributes the decline of numerous Hawaiian species - from moths to damselflies to snails - partially to the introduction of biocontrol agents. "In some cases, the agents become pests themselves," writes Gillis. The real focus, says Howarth, should be on cutting the influx. "Once we close the door on new species introductions, then we can figure out how to control what we already have."

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A new department, The Professional Biologist, began appearing in the July/August 1992 issue of *BioScience*. The premier subject matter for this department was sabbaticals - a time "to redefine objectives, reflect, evaluate your professional performance, and

be creative ... a time during which you can consider the important spiritual and intellectual goals that higher education must pursue for their own sake ..." and a time to "interact with colleagues in different educational and geographical environments and to experience another culture."

The Professional Biologist's verdict is contained in the first column's headline: "A Sabbatical? Do It!"

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Farmers soon may be producing plastic from their potato and sugar-beet crops according to word from Michigan State and James Madison University scientists in *Science*. "For the first time, a plant has been genetically engineered to make something other than a protein - something no other plant has ever made before," according to Christopher Somerville of Michigan State's Plant Research Lab.

The plastic, called polyhydroxybutyrate, is being grown in an experimental plant. PHB, a polyester, could be used as a liner for disposable diapers and for containers. A British company is producing it from bacteria to make shampoo bottles, but this is the first successful attempt to get plants to grow plastic. PHB is similar to polypropylene, a plastic used for molded parts, electrical insulation, packaging, and fibers for clothing; however, PHB is biodegradable and is chemically similar to starch. Both PHB and starch can serve as a way for plants to store carbon.

For 20 years scientists have known about a family of polymers accumulated as storage products in many species of bacteria and blue-green algae. The three genes necessary for one of these bacteria, *Alcaligenes eutrophus*, to make PHB were identified and cloned in 1987 by Douglas Dennis at James Madison U in Harrisonburg, VA. One of the genes also is found in higher plants, including *Arabidopsis thaliana*, a small, quick-growing mustard plant with a very simple genetic structure.

Somerville and colleagues inserted the two key genes from *Alcaligenes eutrophus* into *Arabidopsis thaliana*. They established a new line of *Arabidopsis thaliana* plants with one gene and a new line with the other gene. Then they cross-fertilized the two lines to create a hybrid with both genes. This hybrid then began making PHB in small amounts - in its leaves, stems, and roots.

Somerville said that PHB production is a crucial first step in getting plants to grow a whole family of biodegradable plastics from polymers similar to PHB.

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A less deadly ("hypovirulent") strain of chestnut blight has been found to neutralize the killer strains that have felled the mighty American chestnut trees, once dominant in eastern North America. *Science News*, in its Aug. 8, 1992 issue, reports on use of the less deadly strain, which causes only superficial, temporary sores on the bark, according to Donald L. Nuss of the Roche Institute of Molecular Biology in Nutley, NJ.

A viral infection reduces this fungal strain's ability to destroy the chestnut tree, according to Nuss and a colleague. Their report in the Aug. 7 *Science* describes how making DNA that encodes the virus' RNA, may enable them to harness this virus—or an improved version of it—for controlling chestnut blight. The transformed fungus that results from the transplanting of the virus causes small cankers to develop on a chestnut

"Beginning with the environmental era, the dignity and nobility of the national parks, once seen largely in terms of majestic landscapes, came also to be measured in the precise, objective terms of science. And it has become apparent that, due to human influences from inside and outside park boundaries, the parks' natural resources have increasingly undergone ecological degradation, slipping father from any semblance of pristine conditions ...

"Despite the Service's increasing efforts to address these threats, there has been only limited progress in restoring anything like pristine natural conditions. Thus, while the parks continue to be tremendously popular with the American public, the goal of leaving the parks indeed ecologically unimpaired seems more and more unattainable - moving farther out of reach like a distant, receding star."

From "The Roots of National Park Management: Evolving Perceptions of the Park Service's mandate," by Richard West Sellars, historian with the NPS, Santa Fe, NM, in *Journal of Forestry*, Vol. 90, No. 1, pp 16-19.

stem rather than large, rapidly expanding ones, says Nuss.

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J. Boone Kauffman, a fire ecologist in the rangeland resources department at Oregon State University, reports in the Winter 1990 issue of OSU's *Oregon Agricultural Progress* on his ongoing study of the impact of fire in the rain forests of South America. He describes an ecosystem that is "unraveling" and irrevocably changing.

"Ashes in the Amazon," by Carol Savonen, describes Kauffman's assessment of the situation in Brazil as a matter of more than mere fire ecology. "It is obvious," Kauffman notes, "that rampant deforestation is not a biological problem. It's merely a reflection of social problems with multiple causes."

These multiple causes also produce multiple and far-reaching effects. To quote the article: "An intact rain forest creates its own climate—scientists estimate about one half of all rainfall originates from the moisture given off by the forest itself. When large tracts of land are deforested, local and overall climatic patterns may change. Once the forest is gone, drought may occur, intensifying the probability of fire and decreasing the probability the forest will ever return."

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As if to underscore the possibilities raised in the Boone Kauffman article (see above) the following item appeared in the August 17, 1992 *Earthweek: A Diary of the Planet*, a feature carried in many U.S. newspapers.

"Searing heat and a severe drought have ravaged 78 counties in southern and eastern parts of China's Sichuan province since late June. The official Xinhua News Agency reported that the dry spell has devastated 5.2 million acres of crops and caused a shortage of drinking water for more than 9 million people and an equal number of livestock. An extended drought is causing similar problems in Hubei and Anhi provinces.

"Some of the hottest weather since 1775 has been baking central Europe, worsening the summer drought

# regional highlights

## Pacific Northwest

"Crater Lake NP: Still Beautiful at 90" is the title of the scientific symposium held at the park in May of this year, at which many scientists, who have been studying Crater Lake since a 1982 act of Congress boosted research efforts, reported on their work.

"It's becoming increasingly clear that Crater Lake is a dynamic system (that) changes and fluctuates over time," said Gary Larson, associate professor of forest resources at Oregon State University and leader of the NPS/CPSU there. "Some of these changes, including such things as the water level, clarity, and production of plant and animal life, appear to be cyclical," he said. "There are seasonal, annual, and long term fluctuations, but we're not certain of the exact nature of these cycles ... It's safe to say that at this point research on Crater Lake is still gearing up, not down."

A new role for the lake emerged – as "the world's largest rain gauge." One of the newest projects is using the lake as a barometer of global climate change and learning what effects climate, in turn, will have on the lake, Larson said. For instance, the lake's water level dropped 16 feet during the "dust bowl" of the 1930s. It later rose to levels approximating those of the last turn of the century, and in the 1980s has again dropped about 6 feet.

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New faces and new places in the Region include:

Vicki Snitzler-Neek, as Resource Management Specialist at Craters of the Moon, replacing Shelley Sparhawk, who joins the Resource Management staff at Olympic NP;

Paul Gleason, to Olympic NP as Archeologist (a new position), from the Alaska Regional Office in Anchorage;

Karen Taylor-Goodrich, to a new position as Supervisory Natural/Cultural Resource Management Specialist at Coulee Dam NRA, after completing the Natural Resource Management Trainee Program;

David Elk, from Resource Management at Carlsbad Caverns to a new Resource Management Specialist position at Fort Clatsop National Memorial in Oregon;

Shirley Hoh, from Theodore Roosevelt NM to San Juan Island NHS, to fill a new Resource Management Specialist position;

Hugh McDonald, from Cincinnati Museum of Natural History where he was curator of vertebrate paleontology, to the new Paleontologist position at Hagerman Fossil Beds NM in Idaho;

Marsha Davis, from Jewel Cave NM to the Regional Office, filling the new Geologist position in the Resource Management and Protection division; and

Erv Gasser, from Richmond NBP to fill the position in the Resource Management and Protection division vacated when Steve Gibbons transferred to coordinator of the Region's National Natural Landmarks.

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An item in the August 12 Regional Weekly Highlights reads as follows:

"Last Thursday afternoon a family of five in front of the Nez Perce NHP Visitor Center looked south and saw something large walking in the wheat fields on a hill about a quarter to half a mile away. They went into the visitor center to ask the ranger what it was. Park Curator Sue Buchel stepped outside the VC and confirmed there was something dark, larger than a human, walking in the fields. It disappeared while they went back in to get binoculars.

"Over the hill, another family reported seeing the creature from a distance of about 150 yards. Grover

Crantz of Washington State University, who has researched Sasquatch for 20 years, traveled to the park on Friday. He has called it a good sighting. There were 13-inch footprints in the area. Supt. Frank Walker has fielded media calls from Massachusetts, Pennsylvania, New York, Wisconsin, Missouri, Indiana, Utah, Washington, California, and Alberta, Canada."

## Southwest Region

A cave research program and a study of the feasibility of establishing a cave research institute have been undertaken by the Southwest Regional Office Asst. Regional Director for Planning, as directed by Public law 101-578, dated Nov. 15, 1990. The study will result in a report to Congress covering the need for an institute, its purposes, what elements the facility should include, recommended location, its cost and management.

The Division of Natural Resource Management and Science staff is assisting with the study and will incorporate the input of cave specialists from BLM, USFS, USGS, and from the private sector and several universities. The study is slated for completion by Spring 1993.

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Training remains a high Regional priority. Jerry McCrea assisted Dr. Terry Cacek, the new Servicewide IPM Coordinator in presenting a 40-hour IPM course at Albright in June; the Southwest Region offered an IPM class for Africanized honeybee management in August; and in September the Region's staff joined forces with the Midwest Regional Office staff to present an IPM course for museum curators in Lawrence, KS. Personnel from the Pacific Northwest and Rocky Mountain Regions also attended.

# information crossfile

in the region and causing outbreaks of unhealthy air.

"The water level of Lake Titicaca, located high in the Peruvian and Bolivian Andes, has dropped two feet this year because of drought."

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Researchers are making progress toward a vaccine to combat the tick-borne illness Lyme disease, according to John Travis's "News & Comment" department in *Science* (Vol. 256:1623). Travis cites the June 15 *Proceedings of the National Academy of Sciences*, in which a team of researchers from Harvard and Yale report that mice vaccinated with a protein from the surface of the bacterium that causes Lyme disease (*Borrelia burgdorferi*), successfully fight off infection from tick bites. The bacterium, a spirochete that is transmitted to humans from its natural hosts—mice and deer—by tick bites, apparently is killed by the antibodies triggered by the vaccine. It is suggested that "it might be possible to curtail the spirochete's population severely and limit the spread of Lyme disease by vaccinating mice and deer."

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Richard N. Mack of Washington State University's department of botany reviews in *Science*, June 19, 1992, p. 1699, a new book by R.H. Groves and F. di Castri, Eds., Cambridge University Press, 485 pages,

illustrated, \$125. The book, *Biogeography of Mediterranean Invasions*, (31 chapters) includes reports on work not well known to English-speaking biologists, says Mack, but "it comes at the price of depth on any one topic." Mack deplors a missed opportunity to evaluate the "sometimes obscure literature that reports the circumstances of an immigration" but notes praiseworthy exceptions—the chapters by Kloot and Rejmanek *et al.* on invasive plants in southern Australia and California, respectively, and Blondel's "insightful chapter" on bird invasions in the Mediterranean region.

This book," Mack concludes, "will certainly provide intriguing reading for anyone who is interested in rapidly unfolding biological phenomena."

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College of the Atlantic biologist Dr. Craig Greene and three COA graduates have developed a computer database that indexes all research articles written on natural resources of Acadia National Park and adjacent areas in Downeast coastal Maine. "Because Acadia has been the focus of many naturalists' studies over the past 150 years, the natural history of Mount Desert Island may be the best known of any area of comparable size on the continent," Greene said. "But up until now, no comprehensive bibliography of this information has existed." The accumulated

information will serve as a foundation for future inventorying and monitoring in the Park.

The index is organized by region, species, date, author, and other keywords, and provides an annotated summary of each of the more than 1,000 research articles that have been written on the park, some of them dating back to the 1800s.

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Michael Zimmerman, a biology professor and associate dean of the College of Arts and Sciences at Oberlin in Ohio, reported in a July 1992 syndicated column on the impressive improvements in the Third World's agriculture as a result of shifting from pesticide-based to an integrated pest-management approach. Basing his column on a *Science* magazine report, Zimmerman cites a 10 percent increase in Indonesia's rice field harvests, plus "a huge decrease in capital outlay for chemicals, and an untold diminution of pesticide-related illness."

The bad news came from David Pimentel, one of the world's leading agricultural experts and a biologist at Cornell University. Pimentel estimates that more than 500 species of insects now are resistant to pesticides and that the amount of crops "lost to insects has almost doubled during the last 40 years despite a more than 10-fold increase in the amount and toxicity of insecticide" use.

# regional highlights

In addition, the Regional Technical Support Center at U/NM provided a 3-day GIS training workshop in August on the use of Environmental Planning and Programming Language (EPPL7).

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Africanized honeybees are continuing their northward advance. On Aug. 3, 1992, the staff at Big Bend NP was notified that a positive Africanized honeybee identification had been made on bees collected within the park. Identification was made by a specialist at the USDA Bee Research Lab in Beltsville, MD.

The bees were collected on July 21, 1992, from a swarm trap located at Rio Grande Village. Due to genetic variability, this subspecies has a range of behavior; this particular swarm's behavior was not overly aggressive.

Big Bend NP is the second park within the Region to have a confirmed identification of this bee. Amistad NRA was the first. San Antonio Missions NHP probably will be the third, as a confirmed identification has taken place at nearby Fort Sam Houston.

Considerable emphasis will be placed on education, prevention of infestations in and around structures, and management of singular colonies and/or swarms in developed areas. Quarantine of infested counties will sharply reduce the practice of moving beehives and will require significant changes in agricultural practices in Western states, which are quite dependent on migratory beekeeping.

## Southeast Region

Dr. Joseph Clark has been selected to head the NPS/CPSU at the University of Tennessee. The former assistant chief of the Arkansas Game and Fish Commission, Dr. Clark earned his PhD at the University of Arkansas (U/AR), and an MS from U/GA. He served as research coordinator for the AR Game and Fish Commission, has done extensive research on black bear ecology, and was a research technician for the Cooperative Wildlife Research Unit at the U/GA's school of forest resources.

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Dr. Caroline Rogers of Virgin Islands NP has received the Pingree School Alumni Association's award honoring the graduate who has made significant contributions to the quality of life of his or her school and community of fellow man, through extraordinary effort and dedicated service.

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Dr. Stephen Shabica, formerly an Oceanographer for the Southeast Regional Office, now is a Resource Management Specialist for Cumberland Island NS. Rich Dawson, Resource Management Specialist, SERO, has transferred to the USFWS in Atlanta as a fish and wildlife biologist.

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Reports recently published in the Region include: Claxon, P.G. and H.L. Renwick. 1987. *Bibliography of Scientific Research for Cape Hatteras NS*. CPSU, Rutgers-The State Univ. of NJ. NPS/SER/92.

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Van Cleave, R.L., W.G. Beard, B. Shunamon, and J.D. Peine. 1990. *Trail Use Monitoring in Great Smoky Mountains NP: Results from 1988, 1989 and 1990*. Uplands Field Lab. NPS/SER/92-01.

Zoodsma, B.J. 1991. *Distribution and Behavioral Ecology of Manatees in Southeastern Georgia*. Kings Bay Environ. Monitoring Program, U/GA CPSU. NPS/SER/91-03.

## Alaska Region

A gray wolf, tagged in Gates of the Arctic NP& Preserve with radio collar #321, recently was taken by a hunter in Fort McPherson, Northwest Terr., Canada. Alaska wolf #321 was born in 1986 in the central part of the Brooks Range, AK. In 1987, the animal was tagged as part of a NRPP funded world study.

The wolf was located by Canadian scientist in April 1988 and remained in Canada. The straight line distance between capture and kill site was 4343 miles. The longest distance previously known to have been traveled by a wolf in North America is just over 450 miles.

Among the 51 marked wolves in the study, the primary cause of loss from the study area was dispersal, although the population was subject to fairly extensive hunting and trapping.

The evidence points to #321 as being truly "a lone wolf."

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One of the radio-collared wolf packs in Denali NP&P has left its established territory and traveled 140 miles. This pack numbered 14 animals within a 800 k2 territory in the center of the park. Eleven wolves, including 3 radio-collared animals, crossed the Alaska Range and moved through at least 4 other wolf pack territories, along the way making several caribou and moose kills.

While wolf pack forays into other territories have been observed, movement of nearly all of a pack for such a long distance has not previously been recorded in Denali. The pack broke into smaller groups during the summer. Their subsequent movements, including whether or not they return to the park, will be of considerable scientific interest.

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## Western Region

The CPSU at U/AZ announces a newsletter called *Bajada*. Its purpose is to provide a new medium of communication for researchers and managers working in the parks administered by the CPSU at Tucson. The first issue will appear in January 1993. A circular announcing *Bajada* and listing guidelines and deadlines is available to contributors by writing the CPSU or calling (602)670-6896. You may also call or write to have your name placed on the circulation list.

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Tech. Report #45, "Natural Vegetation of Casa Grande Ruins NM, AZ," by K. Reichhardt (40pp) has been published by the CPSU at U/AZ and copies may be obtained by writing there or calling (602) 670-6885.

An article titled "GIS Research in Arizona NPS" by Michael Kunzmann, Phil Guertin, and Tom Potter, was published in the Spring issue (Vol. 4, #1) of *IDRISI NEWS*. It discusses Arizona GIS research and explains why IDRISI was chosen as the principal GIS system to create GIS databases for several of the AZ NP units. For copies of this 2-page article, call (602) 670-6885.

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Mary Ann Madej, Research Geologist at Redwood NP, has two new publications: "Spatial variation in armoring in a channel with high sediment supply," pp. 277-296 in *Dynamics of Gravel-Bed Rivers*, P. Billi, R.D. Hey, C.R. Thorne, and P. Tacconi, eds. John Wiley and Sons. NY 670 p.; and "Cooperative erosion control efforts based on sediment transport trends, Redwood Creek, north coastal California," in *Proceedings of the American Institute of Hydrology Conference*, Portland, OR, 1992.

## Rocky Mountain Region

Leafy spurge (*Euphorbia esula*), a highly competitive exotic species and noxious weed, has continued to spread within Theodore Roosevelt NP (TRNP) despite several years of herbicide spraying, causing significant ecological disruption of native communities and, in some localities, replacing all native species.

TRNP in 1987 began an experimental biological control program consisting of several insect species that are natural predators on leafy spurge in eastern Europe. This year the park initiated an intensive bio-control program, working with USDA Agricultural Research Service (ARS), USDA Animal and Plant Inspection Service (APHIS), North Dakota Dept. of Agriculture, and the ND State University (NDSU).

Recently the park released three different flea beetles - 6,760 *Aphthona flava* at 16 sites (ARS and NDSU), 4,500 *Aphthona nigricutis* at 5 sites (ARS and NDSU), and 2,000 *Aphthona cyparissiae* at 3 sites (ARS). APHIS is continuing to provide the park with information on the testing of identified biological control agents released in the park and their potential effect on native spurge. ARS is clearing 5 additional new species of biocontrol agents through APHIS.

Biological control agents will not eliminate the spurge, but the goal is to reach an acceptable ecological balance between spurge and the native plant communities. Large scale use of biocontrol is probably 10 years away.

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Continued on page 16

# Midwest Identifies Social Issues As Aid In Planning Research Program

By Roak Parker, David Lime and Jerrilyn Thompson

NPS managers face a wide range of management issues that impact both cultural and natural resources. Many of these issues are social in nature. We define social issues as those concerned with the management of human actions and interactions, such as dealing with human-induced erosion along river shorelines, monitoring numbers and types of visitors, developing effective visitor education programs to encourage minimum impact behaviors, and developing cooperative strategies among individual park units and various governmental and nongovernmental agencies.

Social science research can aid resource management in seeking solutions to many social or human issues. But what exactly are these social issues? Are issues unique to individual park units, or do many park units experience similar problems? And which issues deserve priority?

To develop management strategies for social issues in the NPS Midwest Region, the newly established University of Minnesota CPSU was called upon to identify social science research needs and opportunities as they relate to emerging issues within the Region. As a first step in identifying what issues exist and whether or not there are common problems among park units, the CPSU systematically examined 6 major planning documents for the 28 units in the Midwest Region that had completed planning documents.

Planning documents provide direction and focus for park management. Their content and style varies

considerably and often reflects the educational background of the authors. Many are written from a biological perspective, and they focus on the manifestation rather than on the cause of the problem – especially when the problem is caused by visitor impacts. As a result, many social problems and issues may not be readily evident or directly stated. Nevertheless, this effort was viewed as an early and exploratory step to help identify a research agenda and isolate priority issues for study using one source of information.

For each of the 28 parks studied, the contents of each Resource Management Plan (including natural and cultural resources), Interpretive Prospectus, Statement for Interpretation, Statement for Management, and 1990 Outline for Park Requirements were analyzed. All of the social issues or problem statements expressed directly and indirectly in these documents were recorded and later classified into 6 broad categories dependent upon their content:

1. describing use and users;
2. providing for interpretation;
3. describing aesthetic, economic, and psychological benefits;
4. managing visitors;
5. managing external influences; and
6. other issues, not fitting these categories.

Once placed in an initial category, issues were re-examined. Within each of the 6 broad categories, major themes were identified and some categories were subdivided into specific issue groups, such as managing depreciative behavior, determining economic benefits of park use to the local economy, and developing cooperative arrangements with other gov-

ernmental agencies. The range of issues and the extent to which issues are common among park units were identified.

As a check on the responsiveness of our findings, the initial results for each park unit were sent to the park superintendent for review and comment. The superintendent was asked to do 5 things: (1) cross out any problem statements or issues that already had been clearly addressed and resolved, (2) clarify the wording for any problem statement or issue that did not accurately reflect the problem, (3) add any social problems or issues to the list which were not identified, (4) indicate the issues they would like help in resolving, and (5) rank order the issues they had identified in item 4. Comments from the superintendents were used to amend our findings and to more accurately reflect each park's situation.

## General Results

From the 168 documents examined, more than 300 issues were identified, averaging about 10 per park. For example, within the broad category of Providing for Interpretation, more than 100 separate issues emerged. Approximately 85 issues were identified concerning Managing Visitors, and 50 issues were found concerning Managing External Influences. Many of the specific issues in these last two categories occurred in more than one park unit. Within the other three categories, fewer issues were identified. For instance only 23 problems emerged in the category Describing Aesthetic, Economic, and Psychological Benefits, with almost half of these being added by park superintendents during the review process.

The number of issues identified per park unit varied widely, ranging from 47 at Voyageurs NP in Minnesota to one at George Rogers Clark NHS in Indiana. Although the park superintendents added to and amended the issues identified for their units, these changes did not significantly alter the general results.

## A Diversity of Issues

Given the diversity of park settings within the region, a variety of social issues was expected and found. The individual issues identified ranged from the need to control vandalism within the parks to the need to determine the aesthetic value of open spaces.

While there is a great diversity of issues and types of issues, it also is clear that many issues are unique to individual park units. All but one park unit identified at least one issue that was not identified at any other park. Many of these issues focused on the unit's need for research, development, and evaluation of interpretive programming. For example, at Jefferson National Expansion Memorial there is an expressed need to conduct oral histories about the building of the arch as an aid to interpretation. At Voyageurs NP a need was expressed to add authenticity to interpretive programs through interviews with Native Americans.

While strategies and methods to conduct such research may cross park unit boundaries, the immediate value of the research will be to the individual unit.

## Common Issues

Individual park superintendents and managers may be well aware of the problems faced by their own units, but they may be less aware of management problems and issues in other units. To each manager,

**Continued on page 17**

## regional highlights

Wind Cave NP's thistle problem (common to many park areas) cannot be attacked by use of herbicides, owing to the fact that the cave underlies a large part of the park and herbicide contaminated water might infiltrate the cave environment. Thus, the thistle (*Cirsium arvense*), has been manually cut in past years. Dr. Deborah Kendall, Fort Lewis College, is using insects that feed specifically on Canadian thistle to control spread of the plant.

Research and control plots were established and releases of the Canada thistle gallfly (*Urophora cardui*) took place in May and June. Releases of the Canada thistle seedhead weevil (*Larinus planus*) were accomplished in July. Monitoring has shown they are well established and doing considerable damage to thistles in the research plots. A third species, the Canada thistle crown root and stem weevil (*Ceutorhynchus litura*), slated for release, was unavailable. It is hoped this project can continue next year to insure establishment of these species.

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The southwestern subspecies of the Willow Flycatcher (*Empidonax traillii*) has been categorized as a Species of Concern and is being proposed for listing as endangered or threatened. Population declines have been caused by riparian habitat loss and brood parasitism by the brown-headed cowbird (*Molothrus ater*). Surveys now being conducted by the Resource Management division at Glen Canyon NRA and biol-

ogists from Northern AZ/U will give managers the baseline data for understanding and managing willow flycatcher populations along the Colorado.

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Glen Canyon NRA harbors a wide variety of riparian vegetation in side canyons and major tributaries. As part of the ongoing riparian vegetation survey work around the lake, sites will be selected for breeding bird monitoring studies, to start in Spring 1993. This will provide initial baseline data on extent, composition, and status of riparian breeding birds around the lake.

...

Several of the Region's park units are monitoring neo-tropical migratory birds in conjunction with other agencies as part of the national interagency Neo-tropical Migratory Bird Conservation Program. Glacier NP is conducting songbird monitoring in cooperation with the USFS. Zion NP is cooperating with the Utah DNR to monitor birds in riparian habitats, and Glen Canyon's monitoring program will complement efforts by other southwest agencies.

...

The Branch of Research has hired Ed Wick as Endangered Fisheries Program Coordinator with the developing CPSU at Colorado State U in Fort Collins. Wick will concentrate on the 4 endangered fish species in the Upper Colorado River basin.

**Table 1. Selected social issues identified in Midwest Region park planning documents.**

Park Unit	Need to monitor visitor use patterns	Need to reduce and manage depreciative behavior	Need to manage user conflicts	Need for agency cooperation	Need to address issues adjacent to parks	Need to understand economic benefits of park use
Agate Fossil Beds National Monument	x			x		x
Apostle Islands National Lakeshore	x	x	x			
Cuyahoga Valley National Recreation Area	x	x	x	x	x	
Effigy Mounds National Monument	x	x		x		
Fort Larned National Historic Site	x	x	x	x	x	
Fort Scott National Historic Site					x	x
George Rogers Clark National Historic Park					x	
George Washington Carver National Monument					x	
Grand Portage National Monument		x				
Harry S. Truman National Historic Site	x			x		
Herbert Hoover National Historic Site	x			x		
Homestead National Monument	x			x		
Indiana Dunes National Lakeshore	x	x	x	x	x	
Isle Royale National Park	x	x	x			
Jefferson Expansion Memorial National Historic Site	x				x	
Lincoln Boyhood National Monument	x	x		x	x	
Lincoln Home National Historic Site	x			x		
Mound City Group National Monument					x	
Ozark National Scenic Riverways	x	x	x	x	x	x
Perry's Victory International Peace Memorial		x	x		x	
Pictured Rocks National Lakeshore	x		x			x
Pipestone National Monument			x			
St. Croix National Scenic Riverway	x	x	x	x	x	
Scotts Bluff National Monument	x		x		x	x
Sleeping Bear Dunes National Lakeshore	x	x	x	x		
Voyageurs National Park	x	x	x			
William H. Taft National Historic Site				x		
Wilson Creek National Battlefield	x	x	x		x	
Total number of issues identified:	20	14	14	14	14	5

x = Park unit indicated a need to address an issue in one or more planning documents or from review of initial study results by park staff.

the seemingly exhaustive list of problems can appear to be unique. Thus, it would not be surprising to discover that many managers are less concerned with the "unique" issues that arise at other park units.

Our analysis indicates that many specific issues are not unique but are common among park units. Without exception every park unit in the region shared at least one specific social problem with one or more units; park units as diverse in setting and programming as Jefferson NEM and Voyageurs NP share specific social problems and issues.

In Table 1, 6 specific issues illustrate the number and types of issues shared among the units of this region. The need to monitor visitor use comes from the broad category of Describing Visitor Use; the need to manage or reduce depreciative behavior and to understand and manage user conflicts comes from the broad category of Managing Visitors; the need to develop or improve cooperation with other agencies and the need to address issues of adjacent land use come from the category of Managing External Influences, and the need to understand economic benefits related to park use comes from the broad category of Describing Economic or Aesthetic Benefits.

Twenty of the 28 parks indicated a need to know better who are their visitors, how visitors use the park, and to document trends over time (Table 1). Half the parks indicated a need to control depreciative behavior, to manage visitor conflicts, to improve cooperative arrangements with other agencies, and to influence or participate in the management of lands adjacent to and near park boundaries.

The general category Managing External Influences had two components, listed in Table 1 as need for agency cooperation and need to address issues adjacent to parks. Only 7 parks did not show a problem for one of these categories.

Because park units in the Midwest Region share many similar problems, research strategies should be explored in a regional context rather than on a park unit by park unit basis. For example, visitor use monitoring systems could be developed for Great Lakes national lakeshores and parks to document and analyze trends as well as to explore the degree to which visitors use individual or multiple parks in this regional system.

A more specific regional study is underway by the Minnesota CPSU that addresses how these perceptions could be translated into both natural resource

management and interpretation programs. Phase one of this study is focusing on lighthouses at Apostle Islands National Lakeshore, but the study will be expanded to include a series of Midwest Region lighthouse sites that represent a range of natural resource settings, different intensities of visitor use, and varying levels of managerial response. Such regional studies could be more cost effective and could lead to increased generalization of research methods and results within the region and elsewhere in the national park system.

#### Further Studies Are Planned

While this exploratory research found that a wide range of social problems exists within the Midwest Region and that many problems cut across park units, it is not clear how responsive this analysis is with regard to actual research needs. Although information received from the superintendents following their review of our findings helped insure that the data reflect actual conditions in the parks, this research gives only an indication of the emerging issues in this region. Additional research seems warranted to identify emerging issues more accurately and to aid in developing a social science agenda.

A logical next step would be to survey or interview park superintendents, rangers, and other staff about their perspectives on emerging issues in park planning and management. Additional study participants could include private environmental groups, state departments of natural resources, commercial sector providers of leisure services, and selected recreating publics. Such a study of NPS employees in the Midwest Region, and perhaps others, has been initiated by the U/MN CPSU.

A survey or modified Delphi approach, which asks respondents to reply to a series of questions, has been found effective as a way to identify and prioritize emerging issues needing study (Gregersen et al. 1989). An initial open ended questionnaire or letter asks respondents what they think are the most important emerging issues facing NPS managers and users over the next 10 to 15 years. Follow-up questionnaires, interviews, workshops, or focus group meetings are planned.

Workshops or meetings would address prioritized topics in more detail; explore what is known and not known about issues of critical interest; develop priorities for field studies, and develop strategies to attack issues for which adequate information is not currently available. Particular attention would be given to multi-park studies to strengthen broader application and transferability of results among park units. These results could be compared with those from the review of planning documents to aid in prioritizing social science research needs.

This research also will seek to develop and test an information-retrieval system as a means of improving dissemination and application of research results. It is anticipated that one or more priority issues will be studied for which information exists but has not been effectively transmitted to or used by field managers.

Parker is a research assistant, division of recreation, park and leisure studies, school of kinesiology & leisure studies, U/MN; Lime is a research associate and NPS/CPSU leader at U/MN; Thompson is a research specialist with the NPS/CPSU.

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# Mercury Threatens Wildlife Resources

By William Loftus and Oron Bass, Jr.

In recent decades, our national park areas have faced a previously unrecognized threat – the introduction of contaminants from external sources often distant from park boundaries. The effects of long-range transport of contaminants, which contribute to acidic deposition, ozone damage, and impairment of scenic resources, have become obvious to park employees and visitors alike. National parks also have suffered from point and nonpoint source pollutants entering parks in waters shared by cities, industry, and agriculture.

The NPS has responded by instituting research and monitoring programs with the guidance and participation of the Air and Water Resources divisions. NPS also is a major player in the National Atmospheric Deposition Program. Individual parks, to maintain their air and water quality standards as required by the Clean Air and Clean Water Acts, often work closely with other federal and state agencies to monitor physical and chemical parameters.

Although NPS has programs to monitor the status of park air and waters, the contamination situation described in this report strongly indicates that present monitoring programs are inadequate to detect ecotoxigants that accumulate in park biota. This case history deals with mercury, but applies as well to other bioaccumulated heavy metals and pesticides. We hope the mercury case history in the Everglades will demonstrate the need for periodic testing of the biota for contaminants (biomonitoring) to improve chances of detecting a problem before symptoms occur.

Mercury (Hg) is a heavy metal found naturally in air, water, and earth in a number of chemical forms. It is very volatile, easily entering the atmosphere where it may be dispersed widely (Swain, 1989). The biota accumulate mercury in body tissues, through which it is passed to higher trophic levels in the food web (Johnels et al., 1967). Top-level carnivores may accumulate loads at which toxic effects, such as nerve damage, convulsions, and death occur. The U.S. Food and Drug Administration presently sets a maximum limit of 1.0 ppm Hg in human foods. Methylmercury is

the most toxic and accumulatory mercury compound. It is believed to be produced by the microbial methylation of Hg in aquatic systems (National Academy of Sciences, 1978).

The first hint that Hg was present in Everglades NP (EVER) came during the DDT-scare of the early 1970s. Ogden et al. (1974) presented the results of screening a variety of wildlife for pesticides and heavy metals. They expressed concern about the biotic effects of Hg because levels in some freshwater fishes averaged between 0.6 and 0.9 ppm. Levels in eggs from wading birds and alligators ranged from 0.4 to 0.5 ppm Hg, and exceeded 1.0 ppm in some wading bird tissues. Ogden et al. (1974) suggested that the biota be monitored for contaminants every 2 or 3 years, but for reasons unclear to us their suggestion was not heeded.

In 1989, a statewide sampling program for Hg in freshwater gamefish by the Florida Game and Fresh Water Fish Commission revealed that muscle filets from largemouth bass (*Micropterus salmoides*) in the Everglades had the highest levels ( $x > 1.0$ -1.5 ppm) in

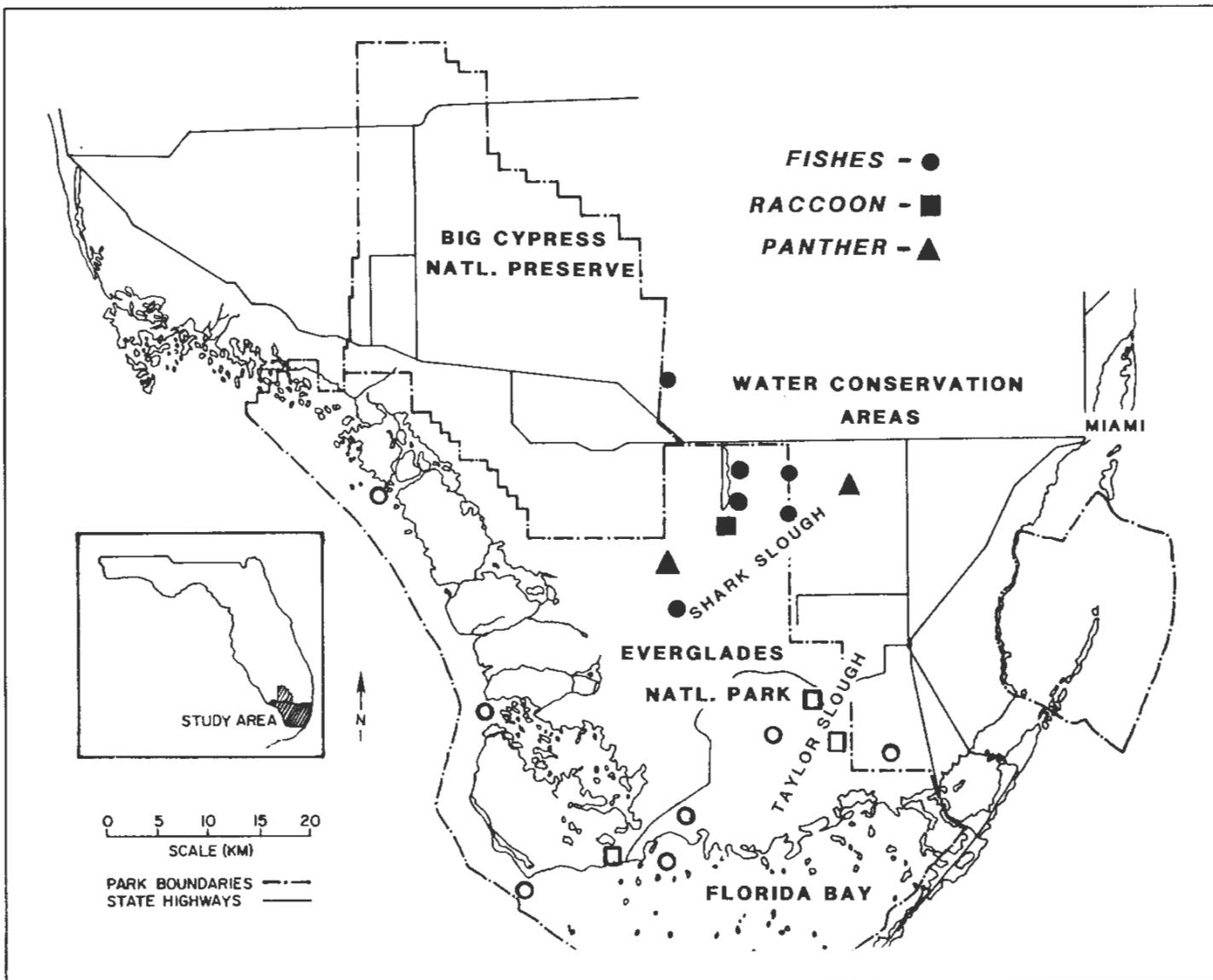


Figure 1. Extreme southern Florida, showing the major drainages in and near Everglades NP. High (closed symbols) or low (open symbol) mercury levels in tissues from fishes, raccoons, and the Florida panther, show the pattern of association with Shark Slough.

# And Human Health in Everglades NP

the state (Hand and Friedemann, 1990). Consumption advisories for fishermen were issued by the Florida Dept. of Health and Rehabilitative Services. EVER cooperated with the USFWS to analyze bass and yellow bullhead catfish (*Ameiurus natalis*) samples at their Columbia, Mo. lab. Bass from Shark River Slough, downstream of the Water Conservation Areas, had the highest levels ( $x=1.706-1.847$  ppm); Taylor Slough drainage bass had lower levels ( $x=0.511-0.603$  ppm) (Fig. 1). Park managers responded by issuing a brochure explaining the threat to human health. The consumption of bass from Shark Slough waters was prohibited and was restricted in other park waters.

Signs warning of contamination were posted at popular angling sites. Because the greatest fishing activity and harvest occur in saltwater areas, higher trophic-order gamefishes like spotted seatrout (*Cynoscion nebulosus*) and gray snapper (*Lutjanus griseus*) were tested next. Fortunately, mercury levels were lower than in the freshwater fishes ( $x=0.112-0.586$  ppm), and seemed to pose no human health threat.

Until late in 1989, the emphasis for action focused on the human health issue. However, this changed with the death of Florida Panther #27 (*Felis concolor coryi*) in the summer of 1989 in Shark Slough (Fig. 2) (See *Park Science* 10(4):15). Autopsy results were inconclusive but revealed that the cat had regurgitated prior to death. Results of the liver scan revealed an incredible 110.0 ppm of Hg, much higher than liver values from panthers killed by automobiles or other causes. Again, the Shark Slough link was evident.

Mercury contamination in this highly endangered species is of great concern because of its small population, estimated at fewer than 30 individuals in the wild. Blood and hair samples taken from free-living cats using Shark Slough showed a similar pattern of high Hg levels (Fig. 1). Bioaccumulation of Hg through the panther diet was suggested as the source for the high levels. Panther #27, which lived in the Shark Slough area, fed heavily on raccoons (*Procyon lotor*) and alligators (*Alligator mississippiensis*), which in turn, fed on fishes and invertebrates. Panthers in other areas prey on whitetail deer (*Odocoileus virginianus*) as a staple, and deer have very low Hg levels (Roelke et al., 1992).

The next step in the investigation determined that raccoons from Shark Slough had higher levels than those living elsewhere (Fig. 1). Alligator samples await analysis but are likely to be high. In the northern Everglades, the alligator hunting season was closed because of unsafe Hg levels. Most recently, great egrets (*Casmerodius albus*) and other waders from Shark Slough had the highest Hg levels of samples tested from south Florida (M. Spalding, U/FL, pers. comm.).

Two major questions raised by this episode are (1) what are the sources of Hg contamination, and (2) what factors contribute to its mobilization and cycling in the environment. An association of high Hg levels in animal samples from Shark Slough is the presence of peat or muck soils in the central depression of the Everglades. In studies of Hg contamination in Scandinavia and the northern U.S. (Swain, 1989; Hand and Friedemann, 1990), association between peat substrates and high Hg levels has been indicated, especially when the peats were mixed or disturbed in some way. Presumably, disturbances liberate Hg stored over time in the peats, making it available for methylation and food-web transfer.



Figure 2. Remains of Florida Panther #27 found dead in Northeast Shark Slough.

The northern quarter of the original Everglades system, known as the Everglades Agricultural Area (EAA) was converted to agriculture decades ago. Two major farming activities in the EAA which may release Hg by disturbing the soils are sugarcane production and sod growing. Before the sugarcane harvest begins, thousands of hectares of fields are burned, sending huge plumes of smoke skyward. The processing mills are fueled by burning cane wastes. A recent report showed that sugarcane tissues contain Hg at levels of 0.03-1.2 ppm (Simons, 1991). As part of the growing cycle, the fields are alternately flooded and dried, leading to rapid oxidation of the peats and the release of stored Hg. Sod production in the EAA also results in peat disturbance and loss. The liberation of either natural or anthropogenically produced Hg from storage in peats may be a major source of contamination elsewhere in the system.

The metropolitan and agricultural areas of Florida's east coast, from Palm Beach to Homestead, are home to more than 4 million people, who use Hg in products such as batteries, dental materials, and fungicides in latex paints. All these uses represent *nonpoint* sources of a volatile metal easily transported by winds. There also exist *point* sources of Hg, such as fossil fuel-fired power plants (Joensuu, 1971) and waste incinerators. A study contracted by the NPS Air Quality division estimated that one of the power plants may emit several thousand kg of Hg annually (Gough et al., 1986). Another study, which modeled wind tracks over the Everglades in summer and winter, demonstrated that Hg emitted along the east coast would be transported over the Everglades (Segal et al., 1986).

Biocontaminant sampling and research is costly; unfortunately most parks do not have the fiscal resources to address this issue. EVER is participating with the state task force assigned to address and manage the episode, but the task force suffers from insufficient funds. To continue periodic monitoring and research, NPS must fund some of the work. The implications of mercury biocontamination are frightening. If we do not understand the sources or the processes, there will be no way to correct them, leaving the region with a chronic contamination situation.

Because of the potential threat to the few remaining

wild panthers in the Everglades, the Florida Panther Interagency Committee has recommended removal of at-risk panthers into captivity; no action has yet been taken. The past few years have seen notable reproductive failures and some developmental anomalies in alligators and wading birds as well. Interpretation of these findings is confounded by the coincidence of several years of extreme drought, but because of the evidence, the synergism of Hg must also be considered.

National parks are not immune from the waste products of the society surrounding them. The lesson of the Hg incident is clear. Even if air and water quality monitoring is intended to measure heavy metal or pesticide levels in the environment, those levels may be so low that their potential impacts on wildlife are not appreciated. We believe NPS must fund periodic biomonitoring for contaminants to identify problems *before* symptoms appear. The most efficient means is by sampling indicator organisms near the top levels of food webs, where symptoms are most likely to be manifested. The price of ignoring contaminant biomonitoring is the potential of discovering that the biotic resources of the park are being quietly but inevitably poisoned.

Bass is a Wildlife Biologist and Loftus is a Fishery Biologist on the staff at Everglades NP.

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# Study Links Big Cypress Fox Squirrel To Golf Courses

By Patrick G.R. Jodice and James R. Snyder

The Big Cypress fox squirrel (*Sciurus niger avicennia*) is one of the distinctive animals of Florida's Big Cypress National Preserve (BICY). One of 10 subspecies of fox squirrel, the Big Cypress fox squirrel (BCFS) is endemic to southwest Florida, with a large portion of its range occurring in and around BICY. Although fox squirrels as a species have been well studied since the early 1900s, southeastern fox squirrels have received little attention. Howell (1919) first described the BCFS, and Moore (1956, 1957) published short accounts of its natural history. Williams and Humphrey (1979) conducted a field survey based on interviews with local residents and found that densities of BCFS were very low.

Concern over the animal's status was sufficient for Florida to prohibit hunting in the 1970s and place it on the state's threatened and endangered species list. A resource inventory and analysis done soon after creation of BICY (Duever et al. 1979) expressed optimism that elimination of fox squirrel hunting and improved law enforcement would allow the BCFS population to increase. Unfortunately, in the 1980s some well known local populations disappeared and the number observed in the Preserve did not increase. The animal is currently a candidate for federal listing.

## Squirrel Project Funded

In 1968 BICY received funding for rare and endangered species research, developed a statement of work for a fox squirrel study, and contacted Dr. Stephen R. Humphrey of the Florida Museum of Natural History, U/FL. He developed a proposal to study the distribution and habitat use of the BICY by the squirrels. The project also planned to recommend methods for a monitoring program and management actions that would benefit fox squirrels in the Preserve. Field surveys were to be conducted over a 1 year period and data on population locations, density, diet, and habitat use were to be collected.

The senior author (Jodice) arrived in south Florida as a graduate research assistant in January 1989, to carry out field work. He began surveying a large system of pinelands in the BICY interior. Within a few weeks he located one fox squirrel at a pineland/cypress ecotone, but although the site was visited daily for the next few weeks, the squirrel was not seen again. Surveys continue throughout BICY, but it was several weeks before the next squirrel was sighted. Densities seemed low indeed!

## Mercury Threatens

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*Bromeliad clumps like this one, on the trunk of a cypress tree, are the temporary nest sites of choice for fox squirrels. (Photo by Jim Snyder.)*

It became apparent that field surveys would not yield the quantity or quality of data needed. Surveying for squirrel leaf nests, a proven technique for locating squirrels elsewhere, also was unsuccessful. After 4 months we had little more information than when we started and less than 8 months to go before the end of the allotted field time.

## Golf Courses Eyed

We began to focus on other populations of BCFS. We knew there were fox squirrels living on and around golf courses in the rapidly developing Naples area 50 km west of BICY. The animals were easy to locate and observe, and preliminary surveys raised interesting issues. For instance, only certain golf courses in town had fox squirrels. Golf courses also seemed to supply a wide variety of food (mostly in the form of exotic plantings) not available in BICY. We saw the golf courses as an opportunity to gain valuable natural history information on mating, daily and seasonal activity, and diet.

We decided to invest some time in the golf course populations. By spending 1 or 2 days a week on the golf courses we hoped to supplement our knowledge of BCFS and gather information on an important segment of the subspecies. Time constraints and lack of natural history knowledge led us to focus on squirrel activity patterns and diet at just 4 well-populated courses.

In the summer of 1989 another opportunity presented itself. A Naples resident was complaining about a group of fox squirrels living around her yard and eating her bird seed. She asked if the Florida Game and Fresh Water Fish Commission could remove them. Aware of our ongoing research, the state contacted us and we decided to relocate the squirrels to suitable habitat within BICY. We trapped, radio-collared, and released 5 squirrels over 3 months. We hoped this

translocation would (1) lead us to other fox squirrels, and (2) provide insight to habitat use and diet.

## Ranges Expanded

Near the end of our scheduled field season a modest increase in funding made it possible to collect a full year of golf course data and 8 months of radiotelemetry data. Results from the translocation showed that fox squirrels could cover large distances in short time periods. They traveled both on the ground and through the trees. Much of this movement may be due to the squirrels' relocation; nevertheless it demonstrated their ability for extensive areal coverage.

Although comparisons with other studies are complicated by differences in methods of estimating home range size and the fact that these squirrels were translocated, it seems that *avicennia* may be using a larger home range than fox squirrels in other areas. The mean of 2 translocated BCFS home ranges was 59.6 ha (conservative estimate). This is greater than any other home ranges reported for all subspecies of fox squirrel. We feel that the habitat mosaic of BICY (predominantly pine, cypress, and mixed-swamp forests) presents a sparser food source for BCFS than for fox squirrels in typical pine/hardwood habitat. This could cause home-range sizes and movements of BCFS to be greater than those of fox squirrels in other habitats (Jodice 1990).

Habitat use of translocated fox squirrels varied among seasons. The translocated fox squirrels used wetter habitats (cypress and mixed-swamp forests) until water levels receded in mid-January. As water levels decreased, fox squirrels foraged predominantly on the ground.

From mid-January through mid-April (the termination of telemetry studies), fox squirrels were often observed digging shallow pits at the base of pine trees, indicating that they were obtaining hypogeous fungi, an important winter and early spring food item for southeastern fox squirrels (Weigl et al. 1989). Few other foods are available in these months. Pine seeds, a staple summer food, are not available until early June.

## Nesting Behavior

Perhaps the most important information obtained from the telemetry project dealt with fox squirrel nesting behavior. Translocated fox squirrels rarely used leaf or cavity nests, but instead nested in cabbage palm crowns and in clumps of bromeliads (tropical epiphytes in the pineapple family) growing on cypress trees. The latter two nest types require little or no construction. This may allow fox squirrels to range over large areas without the need to build nests on a daily basis (an activity that could take up to 2 hours). Squirrels (both fox and gray) often strip bark from cypress trees for incorporation into the cabbage palm or bromeliad nest (Jodice 1990). Surveying areas for stripped cypress trees will become a useful technique for locating squirrel activity in BICY.

One translocated male fox squirrel did lead us to a "native" fox squirrel. In mid-March we located our radio-collared fox squirrel pursuing a female in a previously unsurveyed area. We located 2 nests and observed the female trying to raid a bluebird nest. We were unsuccessful in trapping that female for telemetry, but we gained valuable information and developed new ideas for trapping.

The above data from translocated fox squirrels may

## Fox Squirrel Study

Continued from page 21

provide insight into habits of resident fox squirrels. Habitat use and home range size of resident Big Cypress fox squirrels still are unknown. However, should this information become available, even a qualitative comparison between resident and translocated fox squirrels would shed valuable light on the feasibility of future translocation projects.

### Adaptability Demonstrated

The results of the golf course project indicated how readily fox squirrels have adapted to a situation very different from their natural habitat. There were seasonal differences in the amount of time golf course squirrels spent foraging or inactive, but the differences were not correlated with seasonal changes in either diet or weather. These results indicate that food may not be seasonally limiting to fox squirrels on golf courses that have mixtures of native and exotic plant species.

We speculate that the seasonal shift in time spent foraging may relate to the breeding cycle, specifically young-rearing. Copulation was observed in early and mid-July 1989. The 42-day gestation period of fox squirrels would have placed births in mid-August through early September and lactation through November. During lactation, energy requirements of female fox squirrels increase, resulting in increased foraging time (Weigl et al. 1989) as we observed in the early fall.

The golf courses we studied in southwestern Florida, with their exotic species and artificially maintained habitats, provided fox squirrels with relatively stable food sources... unusual both in its diversity within seasons and its uniformity among seasons. Unlike fox squirrels in natural habitats in the southeastern U.S., fox squirrels on golf courses did not rely on any single food item for a season (Jodice and Humphrey in press). Instead, they relied on various planted fig species throughout the year. Exotic queen palms and bottlebrush also were important food items.

Native food items of importance were pine seeds (July-September) and cabbage palm fruits (December and January). Cypress cones, a primary food item for fox squirrels in BICY, were rarely observed being eaten on golf courses. Cypress may not be a preferred food, but one consumed only when little else is available (as seems the case in many areas of BICY in the autumn months).

### Questions Remain

Questions remain about the long-term viability of golf course populations of fox squirrels. It is possible that existing populations are taking advantage of natural habitat still existing on undeveloped lands adjoining the golf courses, and it is certain that continuing development will greatly reduce the availability of this natural and semi-natural habitat to urban squirrels. S.R. Humphrey has submitted a grant proposal to the Florida G&FWF Commission's Nongame Wildlife Program to address this issue.

Given the low density of BCFS in BICY we recommend that a more extensive study of fox squirrel distribution be carried out opportunistically. In addition to reporting fox squirrel sightings, field biologists working in red-cockaded woodpecker colonies or searching for panther sign also can look for stripped bark on cypress trees and gnawed pine cones in the summer months.

Capture and radio-collaring of some of the elusive resident fox squirrels will be necessary for adequate study of habitat use, food habits, and population biology in the Preserve. In the meantime, the Preserve's aggressive prescribed fire program is likely to enhance

# "Borrowing" Trouble

*Editor's Note: The following article, while it does not describe scientific research, certainly has resource management as a central theme. It came from Einar S. Olsen, Senior Environmental Protection Specialist with the NPS Washington Office of Mining and Minerals Branch and focuses the management spotlight on a problem heretofore not dealt with in these pages.*

Imagine this situation. You pull your car into a park overlook area. You have great expectations for the view of the broad valley and rugged maintain range, which rises abruptly on the valley's far side. But the scene and serenity are disrupted by a most unexpected obtrusion—a gravel operation, located in the floodplain of a river that bisects the valley. The noise from the stone crushing equipment and the constant arrival and departure of trucks hauling gravel to and from work sites is impossible to ignore. The view seems washed out, due to dust from the operation; the waters downstream are not as clear as those above the pit.

This is not an inholding or even a non-federal mineral operation on federal land. This is a National Park Service administrative borrow material site.

While this illustration may exaggerate somewhat, in-park use of borrow for administrative purposes is marring scenic views and needlessly damaging park resources. Borrow sites provide needed sand and gravel for park projects, including road, trail, and building construction and maintenance. Yet poorly developed and reclaimed borrow sites can have significant impacts on park resources, including degradation of water quality and stream channel stability, degradation of aquatic and terrestrial habitats, creation of conditions that promote invasion of exotics, disruption of wildlife, destruction of cultural resources, and the jarring of visitors' experiences.

While the Service is usually diligent in its protection of resource and visitor values, we do not always apply the same level of scrutiny to NPS projects that we apply to threats caused by others. This may result from

habitat quality by maintaining open, healthy pinelands.

*Jodice was a graduate research assistant with the U/FL Dept. of Wildlife and Range Sciences; he is now a Regional Nongame Biologist with the Florida Game and Fresh Water Fish Commission. Snyder is NPS Research Biologist at BICY.*

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the belief that since the project is being conducted by NPS, the impacts must be minimal or nonexistent. Unfortunately, in the case of administrative borrow sites, this has not been the reality. At several such in-park sites the NPS has violated the Clean Water Act and been ordered to cease operation.

Of several reasons for these shortcomings, one may be a result of problems with interpreting NPS *Management Policies*. Another may be the desire, for economic reasons, to use the closest gravel source. Also, local governments may pressure parks to use in-park sources so as not to deplete gravel sources in the surrounding communities.

NPS use of in-park borrow has not gone unnoticed by the conservation community. Non-governmental organizations always have advocated that administrative borrow sites should not exist in parks at all, regardless of importation costs of materials from other sources. Further, these organizations claim the NPS has violated various environmental laws and failed to follow its own policies.

As a result, the NPS Director issued *Special Directive 91-6* on Aug. 5, 1991, providing direction to parks on in-park use of borrow. The Directive's purpose is to ensure that all necessary issues, including economics, are considered prior to developing borrow pits, and that decision making is well thought out by park managers. The policy direction for the Directive comes from NPS *Management Policies*, Chapter 9, Page 4.

The Directive was prepared by a work group consisting of individuals from park natural resources and maintenance divisions, Regional Offices, Denver Service Center, WASO Water Resources Division, and WASO Mining and Minerals Branch. The final version was approved by the Director after being reviewed by the Regional Offices and parks.

The overall responsibility for implementing the Directive rests with the parks. If you have questions regarding it, please contact me, Einar Olsen, Mining and Minerals Branch, WASO, at 202/343-4968.

## In The Next Issue

The U.S. Geological Survey will provide several articles based on earth science research in national parks. An assessment of dams and natural resources in NPS lands will overview the national program and describe the Lawn Lake Disaster at Rocky Mountain NP; the impacts of fires on water quality and sediment in Yellowstone NP will be described; other articles will deal with flow and sediment transport in the Colorado River between Glen Canyon Dam and Lake Mead, the long-term water quality of Lake Powell, stream biogeochemical responses to global climate change in Rocky Mountain NP, and 100 years of environmental change in the Grand Canyon.

Additional titles scheduled for Winter include "High Altitude Mountaineering at Denali NP: Visitor Profiles and Management Preferences" by Alan Ewert; "A Window to the Past: Prior Resource Management Provides a Framework for the Future" by Carol McNulty-Huffman; "Ecology of the High Mountain Black Bear Population at Rocky Mountain NP in Relation to Land Use" by Henry E. McCutchen; "Fort Matanzas National Monument: Home of the Anastasia Island Beach Mouse" by Philip Frank.

# Marine Debris on NPS Beaches: A Plastic, Glass, Metal Nightmare

By C. Andrew Cole

The problem of marine debris has been around as long as humans have been discarding their solid wastes into the oceans. Lately, debris has become globally ubiquitous. Recent disclosure of medical wastes found on eastern beaches has heightened concerns about marine debris for both the general public and the scientific community.

Many environmental groups have shown concern. Each year the Center for Marine Conservation (CMC) sponsors a nationwide "Beach Sweep." This coordinated effort rallies volunteers for a few hours to pick up and catalog beach debris. Although the data from these efforts have been useful and have provided some important insights into the nature and variety of the problem, they are largely anecdotal (CMC 1990), and results from year to year are not necessarily comparable. Also, the sweeps being about a year apart, they leave considerable doubt as to what goes on between sweeps.

On the federal level, the National Marine Fisheries Service (NMFS) began systematic studies of derelict marine fishing debris in the early 1970s (Merrill 1984, Johnson and Merrill 1988). In an effort to expand on that information and generate a broader data base, NMFS and NPS have joined forces since 1988 to conduct a 5-year pilot program to monitor debris at 8 park units. Both agencies figured the NPS could provide relatively unaltered beaches for assessing types and accumulation rates of marine debris. The National Park Marine Debris Monitoring Program (NPMDDMP) has been under way since fall 1988. This article describes some of the information realized to date.

## Study Sites

Eight park units have been involved in the monitoring program. Olympic NP (OLYM) and Channel Islands NP (CHIS) represent the Pacific coast. Padre Island National Seashore (PAIS) and Gulf Islands National Seashore (GUIS) exemplify the Gulf of Mexico region. Canaveral National Seashore (CANA) and Cape Hatteras National Seashore (CAHA) illustrate the southeast Atlantic coast, while Assateague Island National Seashore (ASIS) and Cape Cod National Seashore (CACO) portray the northeast Atlantic coast. For the fourth year, the program has added Virgin Islands NP (VIIS), and is considering addition of Fort Jefferson (FOJE) in the Dry Tortugas, pending funding.

## Methods

By using standardized survey methods and forms developed by NMFS and modified by the NPS, each park has been collecting data on debris since December 1988 (except for PAIS, as explained below). Although NMFS is primarily interested in plastic debris, the NPS is interested in all kinds, and so measured debris types include plastic, glass, metal, cloth, paper, and leather (the last 3 categories are typically lumped as "other"). In any one sample, therefore, 61 plastic, 5 glass, and 9 metal variables can be measured (along with cloth, paper, and leather).

At each park (again, except for PAIS), a minimum of 5 one kilometer beachers are surveyed. Selection of survey beaches considered accessibility, representation of regional conditions, distance from significant public access, and a uniform substrate and topography.

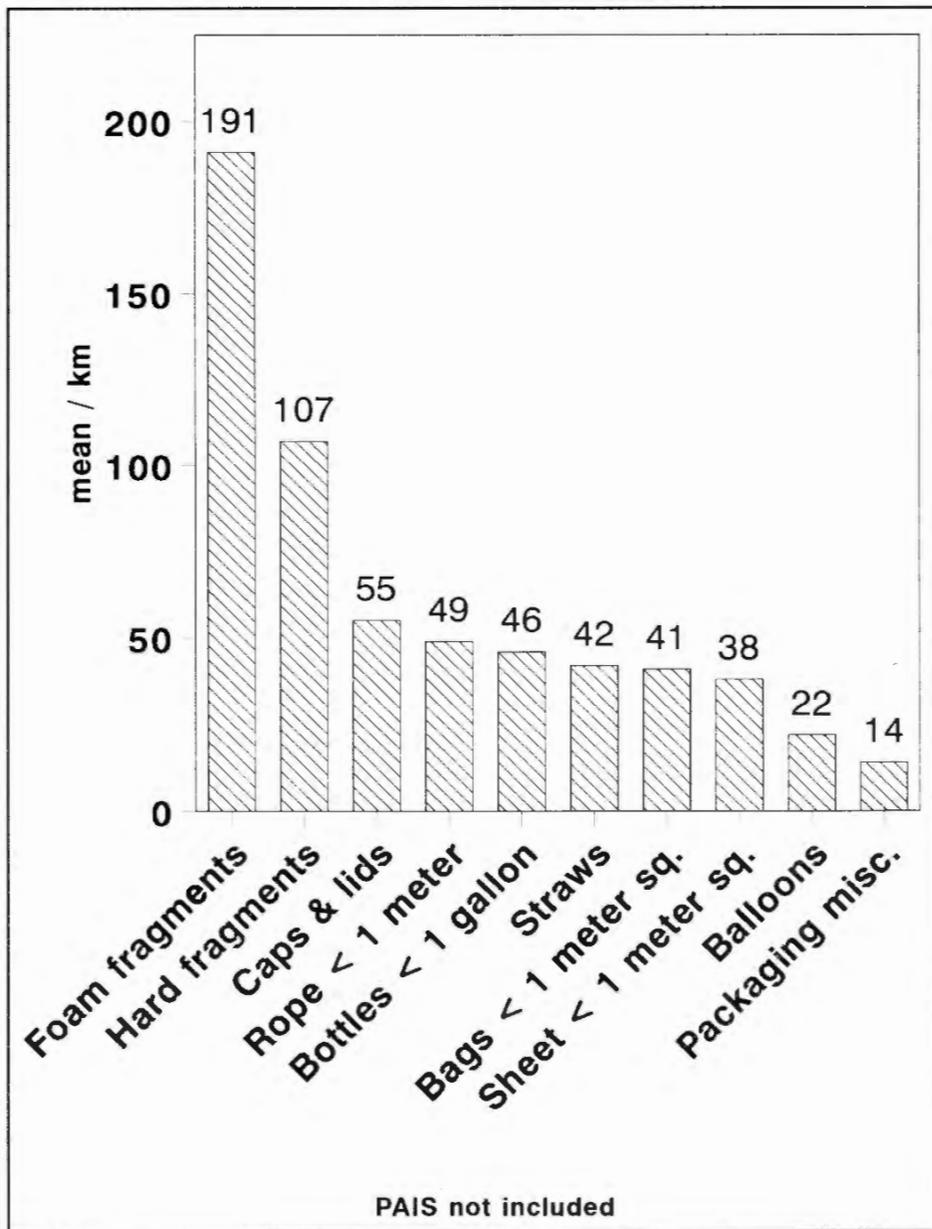


Figure 1. Ten most abundant plastic items of marine debris on the seven NPS sample sites.

On a quarterly basis, beaches are surveyed from the water's edge to the seaward limit of terrestrial vegetation, or to the base of a dune or a cliff. All debris visible from a walking height, and greater than 5 mm in length, is collected and recorded. Any item less than 1/2 its original size is considered a fragment. Hard plastic fragments, therefore, can be very large, unlike foam fragments, which typically are fairly small. This results in not including hard fragments as ingestible plastics, although quite clearly some are.

Ingestible items are those we feel are small enough to be readily eaten by marine wildlife. Entanglement items are those large enough to entangle marine wildlife. In certain cases (e.g. rope < 1 meter in length) a judgment call was made not to include the item as

entangling. If possible, all debris is removed from the beaches, thereby allowing for calculation of accumulation rates between samples. If articles cannot feasibly be removed (e.g. a large buried net), they are marked with paint for identification and non-inclusion in future surveys.

The most egregious local conditions are found at Padre Island; so much debris is found there that entire sets of surveys for consecutive quarters had to be canceled. Until recently the park simply did not have the time, money, or personnel to handle the mess. This (and other problems) resulted in the non-comparability of data for PAIS for the first 2 1/2 years of the project. However, a revised sampling protocol specifically designed for PAIS, plus additional outside funds from

EPA, have allowed the seashore to return to the sampling program.

### Results to Date

As expected, most recorded debris at all beaches has been plastic. Values range from 97 percent at OLYM to about 67 percent at CAHA. Of those plastics, most common are foam fragments, hard fragments, caps and lids, rope < 1 meter, and bottles < 1 gallon (Fig. 1). By far the most common entangling item has been pieces of rope, while foam fragments clearly are the most frequent ingestible item found (Fig. 2).

Due to the variability we have encountered, definitive statements as to trends are impossible; still, some trends seem evident. Packaging appears to be declining in abundance, whereas the miscellaneous category is growing. Plastic, as a whole, also seems to be increasing as a percentage of total debris, though for individual parks there does not appear to be much of an increase in total debris (except for OLYM).

Average number of debris items per km varies widely among parks. Although not included here (due to problems already discussed), PAIS clearly has the most debris per km. In those parks where we have comparable, multi-year data, mean numbers of debris items per km range from 1392 (CACO 1990-91) to 223 (CAHA 1990-91).

### Future Directions

It is clear that deposition of marine debris on the 8 parks is a highly variable phenomenon. The information to date, however, does provide useful documentation. For example, few parks seem to have much aesthetic degradation from debris. Even though there may be much of it, generally items are small and relatively inconspicuous.

Levels of medical debris are extremely low. Exceedingly few items have been found and they constitute much less than 1 percent of the total catalogued to date. This is an important finding, as medical debris, when found on beaches, is a public relations nightmare.

Although entangled wildlife catches much of the popular press (photographs of seals caught in nets, fish tangled in 6-pack rings), potentially entangling debris is not that common. Ingestible items, however, are extremely abundant and pose a serious potential threat to wildlife. Apparently much of what becomes fragments is the wide variety of foam products common in coastal settings (coolers and the like). Foam is easily broken apart by wind and waves, generating a profusion of fragments.

Cape Cod has found significant numbers of tampon applicators ("beach whistles") and q-tip straws, apparently arriving by way of sewage disposal from Boston. If efforts to curtail pollution in Boston Harbor continue, such debris on CACO should decline. Few other parks showed much evidence of sewer-related wastes.

### Some Accomplishments

In the middle of this project, it has become obvious that we are a long way from a complete understanding or delineation of the marine debris problem. We can, however, claim several accomplishments.

We have documented, for the first time, the continuous accumulation of marine debris on NPS beaches in all major regions of the United States. We know that plastics overwhelmingly dominate the debris loads deposited on beaches. We have recorded the wide variability in debris deposition and have begun to identify certain common items potentially useful as debris indicators. We have begun to sort out some of the sources of marine debris, though our conclusions still

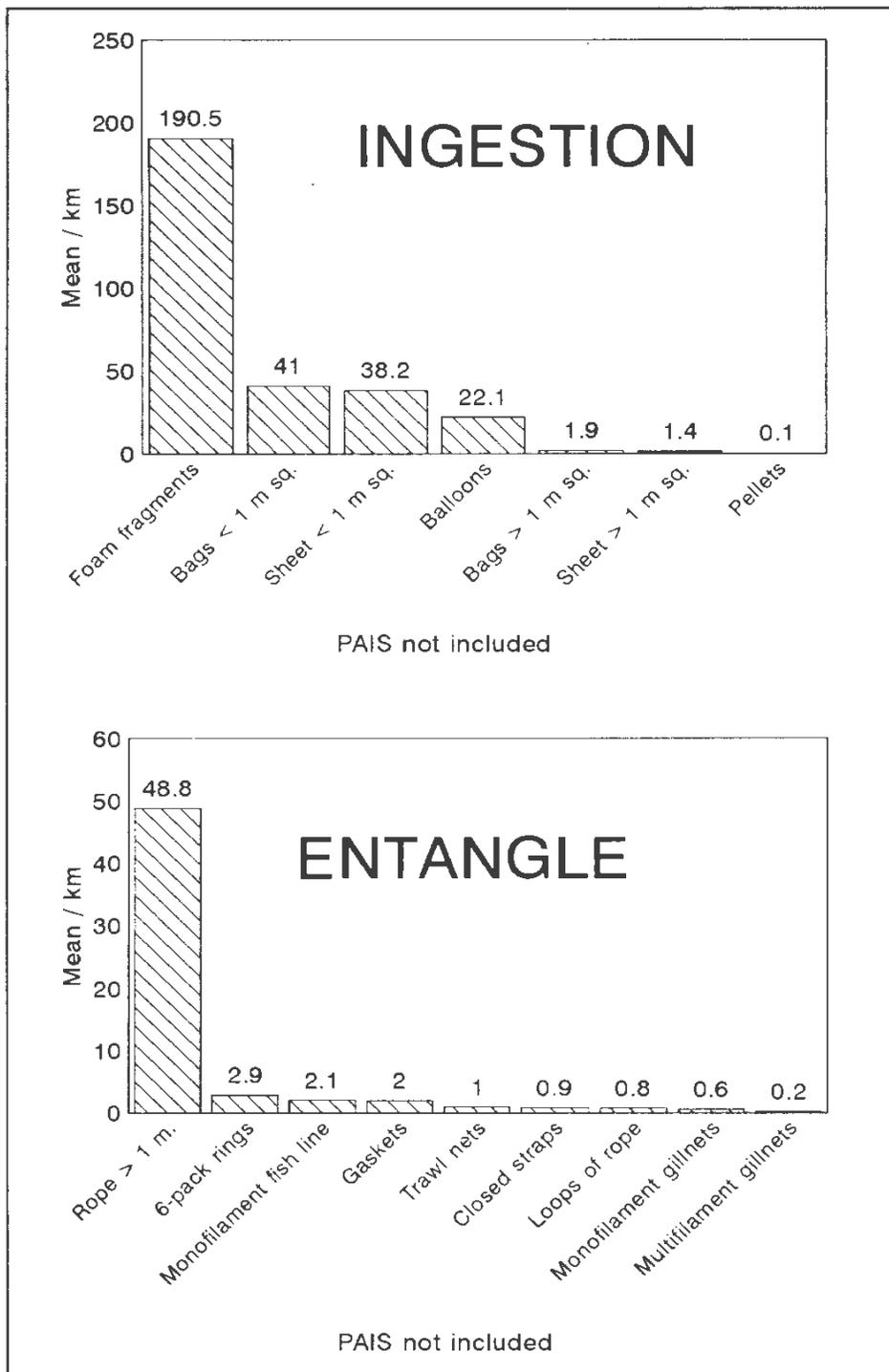


Figure 2. Mean number/km of ingestion and entanglement related plastic debris items found at the seven NPS marine debris sample sites.

are very broad. We have successfully involved NPS employees from several sources and a wide variety of volunteers in a long-term effort, and we have shown the value of using NPS units as educational centers for the marine debris issue.

Dr. Cole is Data Management Coordinator for the joint NPS-NMFS program and an assistant professor at Nova Univ. Oceanographic Center in Dania, FL.

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## National Academy Report on NPS Science Released

The National Research Council of the National Academy of Sciences released its long-awaited report entitled "Science and the National Parks" at a Washington, DC press conference on Aug. 19, 1992. The Council summarized its report with the following statement, "Science and the National Parks is a critical assessment of the problems hampering the current Park Service science program, providing strong recommendations to help the agency establish a true mandate for science, create separate funding and autonomy for the program, and enhance its credibility and quality."

The report outlines 10 major recommendations for the Service to improve its science program, as follows: 1) seek legislation establishing explicit legislative authority for an NPS science program, 2) create an independent research program where all scientists are supervised by scientists, 3) seek a strategic funding increase for science, 4) develop an independent line item in the NPS budget for the science program, 5) establish a Chief Scientist position and recruit a national stature scientist for the position, 6) establish a basic re-

sources information system, 7) establish a competitive grants program, 8) establish an external, high-level Science Advisory Board reporting to the Director, 9) establish a "parks for science" program, and 10) provide for more involvement of researchers in resource management planning.

Asst. Secty. Mike Hayden, Dir. James Ridenour, and Assoc. Dir. Gene Hester jointly hosted a well-attended press conference on August 19 and gave enthusiastic initial responses to the report. Director Ridenour has assigned Dr. Hester to work with Regional Directors Stan Albright and Bob Baker in appointing a working group of senior superintendents to assist them in formulating a series of action items that will help the Service accomplish the recommendations of the National Research Council report. This group began work in early September to accomplish their assignment.

*Denny Fenn, Deputy Director  
NPS Natural Resources  
Washington, DC*

## Wolf Answers: A Second Digest

In response to four questions posed in 1988 by the Senate-House Interior Appropriations Conference Committee, Yellowstone NP researchers prepared two publications: *Wolves for Yellowstone? Vol. I, Executive Summary*, and *Vol. II, Research and Analysis*, more than 600 pages, submitted to Congress in May 1990. *Wolves for Yellowstone? Vol. II, Research and Analysis* is available from the Yellowstone Assn., PO Box 117, Yellowstone NP, WY 82190 for \$16.30, postage paid. An executive summary of the report, Vol. I, is available for \$4.20. *Yellowstone Wolf Questions*, an 11-page digest of *Wolves for Yellowstone? Vol. II*, summarizes that information and is available upon request from the Superintendent, PO Box 168, Yellowstone NP, WY 82190.

The four questions that necessitated these publications were: (1) would wolves be controlled in and out of the park, (2) how would wolves affect their prey in the park and big game hunting in areas around the park, (3) how would wolves affect grizzly bears, and (4) how would wolf recovery zones be laid out?

More questions remained, so funding for further study was made available in 1989. In 1990, Congress directed the Interior Secretary to appoint a Wolf Management Committee "to develop a wolf reintroduction and management plan for Yellowstone NP and the Central Idaho Wilderness Area." The Committee's recommendations went to Congress in May 1991. Later that year, Congress directed that an environmental impact statement be prepared on reintroduction of wolves to Yellowstone NP and Central Idaho, the draft to be completed by May 1993. *Wolves for Yellowstone? Vol. III, Executive Summary*, and *Vol. IV, Research and Analysis*, were submitted to Congress in July 1992. Those 1992 reports present results of studies completed since Vols. I and II were produced. They contain 18 chapters on results of the scientific studies. They do not represent the NPS or USFWS positions, but are responses to information requested by Congress.

A 16-page summary of Vol. IV (750 pp) has been compiled by Norm Bishop, research interpretive specialist, Yellowstone NP, entitled *Yellowstone Wolf Answers - A Second Digest*, and is available from the PO Box 168 address in Yellowstone NP.

## Nadkarni Still 'Up in the Air' As a Tree Canopy Life Specialist

It was way back in 1981, when *Park Science* was still *Pacific Park Science*, that an article on rainforest canopy research at Olympic NP appeared under the by-line of Nalini M. Nadkarni. Two photos of this athletic young lady accompanied the story - showing the author's techniques, with ropes, harness, and Jumar ascenders, in the Hoh rainforest at Olympic.

Twelve years later, Nadkarni appears as the likely heroine of a *New York Times News Service* article by Carol Kaesuk Yoon entitled "Layers of Life." It describes a miniature world of animals and insects that exploit the large bromeliads (members of the pineapple family) that flourish in the canopy high above the jungle floor. Visitors by air include species of bats, wasps, butterflies, and birds, that sip from the rainwater pools or tanks stored deep inside the bromeliad's centerpiece - a tight rosette of leaves. Poison-dart frogs - with flattened bodies and spindly legs perfect for maneuvering through the bromeliad's leaves - bathe, hunt, and raise their young in the pools.

Bromeliads also are home to other small animals, including many yet-unnamed species of beetles and ants, some of them so tree-loving their feet never touch earth.

Less appealing but important are the tank's many worms, microbes and protozoans with Bromeliad addresses. Examination of these plants has yielded up to 300 different species. "If you take a bromeliad and plunge it out into a petri dish and then look under a dissecting scope, it's just a zoo," Nadkarni said.

Nadkarni now is a biology professor at The Evergreen State College in Olympia. She has worked in the Monteverde Cloud Forest Reserve in Costa Rica, and says it's "exciting to get to the plants in this upper part of the forest that nobody knows anything about."

David Benzing, a biology professor at Oberlin College, quoted in the same article, says that "these bromeliad tanks are providing a major resource for life in the canopy ... Wet forest canopy probably is the

most species-rich of all the terrestrial communities in the world, and bromeliads are really a pivotal part of the whole system."

Bromeliads get all their water from clouds and fogs and from rainwater they manage to store in their tanks. As for nutrients, they foster the generation of their own fertilizer by means of a happy mutualism - the animals swimming in their tanks excrete wastes, while bacteria and insects help decompose and digest leaves and dead bodies that have fallen into the water. All in all, a rich organic soup.

Scientists have found that the bromeliad then feeds out of its own leafy tureen, using specialized hairs to strain out what it needs. These hairs, called trichomes, can grow on the outer leaves as well, enabling the plant to gather moisture from the forest's humid air.

Tree-dwelling ants leave trails leading out from the edges of the bromeliads where they make their nests in the dry shade of the older, outer leaves. Some ant species are so fond of bromeliads that when they build their huge mound nests in the trees, they plant their own bromeliad seeds.

Certain species of the aforementioned poison-dart frog have been seen *only* in bromeliads. Researchers have tracked mother frogs hopping from bromeliad to bromeliad, visiting each nursery pool where they have left a tadpole or two, lowering themselves into the pools to feed their offspring nutritious meals of unfertilized eggs.

Other plants also reside within the bromeliads ... from algae to tiny predacious plants. The insectivorous plants deep in the pools are hard to spot, Benzing said, except when their blooms jut through the surface of the water as they flower. When small unsuspecting insects swim by the plant, they trigger a bladder which pops open, sucking in the nearby water and usually the prey.

These arboreal gardens, of which there are 2,000 to 3,000 species, are so rich that in a single Costa Rica tree the air plants weighed in at more than 300 pounds.

A **biosphere reserve managers meeting** is planned, tentatively for December somewhere in mid-continent. This meeting was recommended by the drafting committee for the biosphere reserve action plan to help finalize this document, and was approved by the U.S. MAB National Committee at its July meeting. The managers will review plans and discuss priorities and coordination of the biosphere reserve program.

This is the first BR managers meeting since the 1984 meeting at Great Smoky Mountains NP. That one, attended primarily by NPS managers, generated considerable enthusiasm and numerous recommendations for the BR program. This year's meeting is expected to provide a similar boost and have wider representation.

The National Committee also approved funding of a number of **research projects**. One was the core program of the High Latitude Ecosystems Directorate – a study comparing caribou management systems in western Alaska and north-central Canada. Completion of the core program of the Temperate Ecosystems Directorate – a comparative study of land use patterns and their ecological effects in the Olympic and Southern Appalachian biosphere reserves – also was approved, along with two projects complementary to the latter on water quality and computer integration of interdisciplinary research for application in land use assessment.

**Five additional projects** were funded: (1) community involvement in management decision making for the Porcupine caribou herd; (2) long-term sustainability of Atlantic white cedar swamps in the Pinelands BR; (3) optimal design of marine reserves: ecology and economics (with testing of the design approach at Channel Islands NP); (4) social-ecological interaction

## Stottlemeyer, Doren and Wade Receive Awards

Robert Stottlemeyer, Water Resources Division, WASO, was named recipient of the Director's natural resource-related Award for Research; Robert Doren, Everglades NP was selected for the natural resource Management Award, and Bill Wade, Shenandoah NP, was named Superintendent of the Year for natural resource stewardship.

Stottlemeyer's research "contributes to understanding specific park ecosystems, especially in Alaska and Midwest parks, and to the fields of forest vegetation, nutrient dynamics, biogeochemical cycling, and global climate change," according to the award. Doren's selection was based on his work on the exotic plant management/wetlands rehab project in the Hole-in-the-Donut area of Everglades, its subsequent identification of the area as a mitigation bank, and its receipt of a general permit for additional restoration work. His work in exotic plant management has been recognized by his election to the chairmanship of the Exotic Pest Plant Council.

Wade was recognized for his commitment to resource management and scientific data, as demonstrated by his use of base funds to create and fund a separate resource division, professional positions, and research. His support has provided the park with the capability to compete favorably for other fundings as well. Shenandoah has been chosen as a pilot monitoring park by the Servicewide I&M Program.

in land use decisions in two western Oregon drainage basins; and (5) sustainable forestry at Sian Ka'an Biosphere Reserve, Mexico (including effects on neotropical migrants and other birds). The U.S. MAB budget exceeded \$1 million for the first time in FY 1992.

Two regions are receiving new MAB-related attention. A feasibility study with interagency funding will examine the linking of BRs with other areas in the **Colorado Rockies** to address regional resource issues. The Nature Conservancy has the lead on this study. Land use changes in the **western Sonoran Desert border area** will be the subject of a "regional forum" Oct. 22-25 at Ajo, AZ. Organized by the Sonoran Institute and the Lincoln Institute of Land Policy, this meeting continues the dialog on regional resource concerns begun in the late 1980s by Carlos Nagel under MAB auspices.

The image people have of the biosphere reserve is still varied and often does not match the MAB program's vision. This is revealed in preliminary **results of a survey** conducted by Bill Gregg, NPS MAB Coordinator, and Erica Serabian. Only about a third of U.S. BRs, including NPS and other sites, have responded so far, but certain views can be distinguished. BR designation often is considered a recognition of site significance rather than a framework for cooperation. Also, some managers (not NPS) see their BRs primarily as research sites, operating largely in isolation from their neighbors.

A more balanced view – that of the BR as a place where research and cooperation both are conducted in the service of regional needs – tends to be held by managers of the more recently designated biosphere reserves and those with a history of BR-related cooperation. Perhaps the survey also tells us that the situation and history of each BR are unique, and may favor certain BR functions over others. For some sites, evolution toward a full-fledged biosphere reserve may be naturally slow.

**Napier Shelton**  
NPS Washington Office

To the Editor:

In June (23-25) a meeting entitled "Giant Sequoias: Their Place in the Ecosystem and Society" was held in Visalia, Calif. The National Park Service played an extremely important role in the development and presentation of the agenda. Many of the talks were presented either by NPS folks or by university scientists who have been funded by NPS. It was obvious from the presentations that we were far ahead of the other agencies in understanding the factors influencing sequoia mixed conifer forest dynamics.

This conference was called by the Forest Service largely in response to the enormous protests from environmentalists over the logging of all but the monarch sequoias within USFS groves. It was a politically hot session that culminated in mid-July with President Bush's visit to the nearby Sequoia National Forest (Sandra Key is the new supervisor there!) to endorse the concept of long term protection of the groves. Nevertheless, legislation continues to wind its way through Congress that would actually create a National Monument or similar status for the USFS groves.

The 13 presentations given either by NPS scientists or NPS-funded researchers were part of the following panels: Natural Values, Public Values, and Public Perceptions; Natural Perspectives, Genetic Characteristics, and Ecological Considerations; Giant Sequoia in a Disturbance-Driven Environment; Management Strategies; and Influences on Grove Development. Sequoia and Kings Canyon NP (SEKI) Supt. Thomas Ritter participated in the windup panel on Symposium Results: Views from the Agency Leadership.

I am also extremely proud of the involvement of the SEKI and Yosemite NP staff and cooperators at the Aug. 9-14 meeting in Honolulu of the Ecological Society of America. I am especially pleased to see NPS science starting to become more actively involved in such meetings.

**David J. Parsons**, *Research Scientist*  
Sequoia and Kings Canyon NPs

## meetings of interest

1992

**Oct. 27-30, 19TH ANNUAL NATURAL AREAS CONFERENCE and 14TH ANNUAL MEETING OF THE NATURAL AREAS ASSN.**, at U/IN campus, Bloomington. Contact: Division of Nature Preserves, U/IN, 402 W. Washington St., Rm. W 267, Indianapolis 46204; (317) 232-4052.

**Oct. 27-30, REDISCOVERING AMERICA:** Natural Areas in the 1990s, the 14th Annual Natural Areas Conference, at Indiana Memorial Union, Indiana University, Bloomington. Contact: Indiana U Conf. Bureau, IMU Room 677, Bloomington, IN 47405; (812) 855-6451.

**Nov. 16-20, PARTNERS IN STEWARDSHIP**, the George Wright Society Conference on Research and Resource Management in Natural and Cultural Parks and Reserves, Jacksonville, FL. Contacts: John Donahue, NPS, 18th & C Sts NW, Washington, DC 20240 (202) 208-4274 and Harry Butowsky, NPS, PO Box 37127, DC 20013-7127 (202) 343-8155.

1993

**April 18-23, WESTERN REGION INTEGRATED CULTURAL & NATURAL RESOURCES WORKSHOP**, at Furnace Creek Ranch, Death Valley National Monument. Western Regional Office contacts: Jonathan Bayless, Div. of Park Historic Preservation, (415) 744-3968, and Gene Wehunt, Div. of Natural Resources and Research, (415) 744-3957. The goal is to strengthen both programs in Western Region parks by promoting closer ties between the subject area professionals and development of interdisciplinary approaches to problem solving.

**Mar. 24-27, EIGHTH ANNUAL U.S. LANDSCAPE ECOLOGY SYMPOSIUM**, "Pattern and Process in Landscape Ecology," at Oak Ridge National Lab in Oak Ridge, TN. Nov. 15 deadline for abstracts. Contact: Dr. Monica G. Turner, Envir. Sciences Div., Oak Ridge National Lab, PO Box 2008, Oak Ridge, TN 37831-6038; (615) 574-8282.

# Kemp's Ridley Research Continues

By Donna Shaver

Kemp's ridley sea turtle (*Lepidochelys kempi*) is the most endangered sea turtle species in the world; only about 400 nesting females remain in the population. In the last two decades, Padre Island National Seashore (PAIS) has participated in, and established, several projects to conserve, restore, and study this critically endangered species. Park programs have encompassed all life stages of Kemp's ridley turtles, from incubation of eggs to study and protection of adults.

## Efforts to Establish a Secondary Breeding Colony

In 1978, agencies from the U.S. federal government, State of Texas, and Republic of Mexico began a cooperative program to restore and enhance the Kemp's ridley sea turtle population. Nearly all nesting by this species occurs along a 16 mile stretch of beach near the village of Rancho Nuevo, Tamaulipas, Mexico. However, sporadic nesting has been reported from Corpus Christi, Texas to Veracruz, Mexico. A portion of the restoration program was a 10-year experimental attempt to establish a secondary breeding colony of this species at PAIS through "imprinting" (Fletcher 1982, Shaver 1990).

During each summer, from 1978-1988, approximately 2,000 Kemp's ridley eggs were collected from Rancho Nuevo and shipped to the park for incubation and a large quantity of data, never previously collected for this species, was amassed (Shaver et al. 1989, Shaver and Chaney 1989). Of the 22,507 eggs received, 17,358 (77.1%) hatched (Shaver 1989a, 1990) and 15,875 hatchlings subsequently were shipped to the National Marine Fisheries Service Lab in Galveston, Texas for 9 to 11 months of captive rearing (termed "head-starting"). Overall, 13,454 of the head-started yearlings, experimentally imprinted to Padre Island, were released into the Gulf of Mexico.

## Beach Patrols and Egg Incubation

To date, no turtles released from this project have been found nesting at PAIS or elsewhere. However, it is unknown how many survived after release. Additionally, it is uncertain whether any have attained adulthood yet, since at least 11-12 years may be required for females of this species to attain the minimum nesting size (Zug 1990).

A pair of mating Kemp's ridley sea turtles was sighted within the Mansfield Channel, located at the southern end of the park, on June 3, 1991 (Shaver 1992). This was the first documented observation of mating by this species in Texas waters. Unfortunately, the turtles could not be identified as either wild or head-started and no nests were found subsequent to the mating.

In an attempt to identify whether Kemp's ridleys are returning to nest at PAIS, seasonal beach patrols for nesting sea turtles, tracks, nests, and hatchlings were initiated in 1986. From mid-April through August, park and other local beaches are patrolled from 3-7 days per week. All-terrain vehicles, 4-wheel drive trucks, and surplus military vehicles are used to conduct these rigorous patrols. With the assistance of numerous dedicated volunteers, park staff patrol a 70-mile stretch of beachfront daily, with a total of approximately 6,500 patrol miles being logged each summer.

Beach patrollers also attempt to identify and protect nests laid by sea turtles that are not part of the restoration project. Kemp's ridley, loggerhead, and green sea turtles nest in small numbers along the Texas coast. Twelve confirmed nests were found from 1979-1992,



Kemp's ridley sea turtle hatchling being fed in the PAIS rehabilitation facility.

most at PAIS (Shaver 1989b, 1990, 1991). In fact, during the last decade, more Kemp's ridley nests have been located at PAIS than on any other beach in the United States. Because of the level of park personnel expertise in incubating sea turtle eggs, PAIS incubated or monitored 11 of the 12 nests laid along the Texas coast and all sea turtle eggs laid by captive turtles held in Texas.

## Strandings and Rehabilitation

In 1980, the Sea Turtle Stranding and Salvage Network was established to document, protect, and study sea turtles washed ashore on U.S. beaches. Since the inception of this network, the park has taken an active role and maintained records for all strandings documented on Texas shores.

The park recently took the lead in efforts to detect and protect sea turtle hatchlings stranded on local beaches. Since 1980, more hatchling sea turtles have been found stranded along the beaches of North Padre and Mustang islands than any other area in Texas. Significantly more were located during the summer of 1990 than during any previous summer from 1980-1989 (Shaver 1991) (Fig. 1). Forty (including 23 Kemp's ridley) hatchlings were found alive, but most were weak, injured, and in need of immediate care and stabilization. Beginning in 1990, the park instituted programs to address the three following concerns related to stranded hatchlings: (1) detection; (2) care and



Green sea turtle tracks shown here were found at Padre Island NS on July 14, 1992.

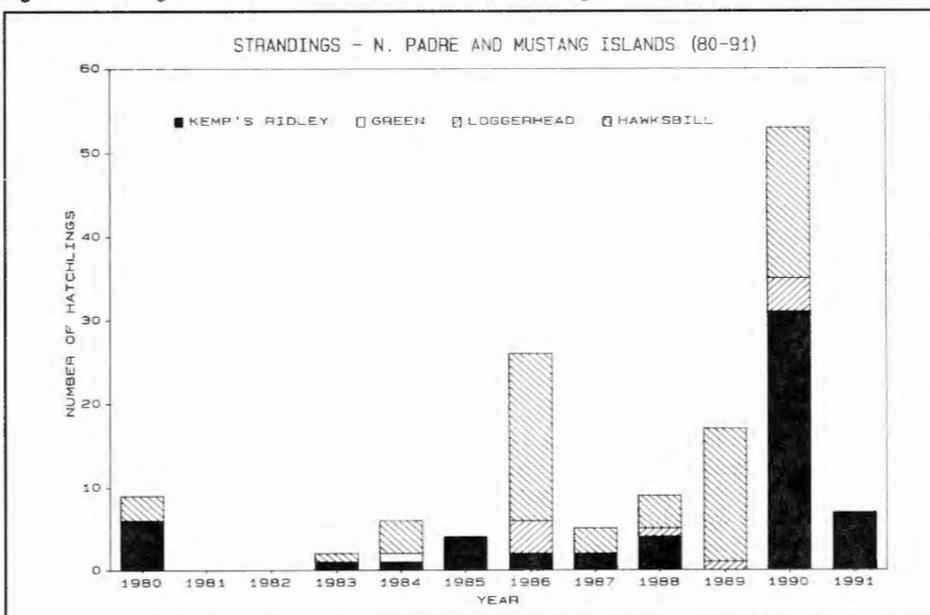


Sean Baker, Biological Technician, conducts a patrol for nesting sea turtles, tracks, and stranded hatchlings.

rehabilitation, and (3) study and determination of age/origin.

Stranded hatchlings are extremely small and difficult to detect. Ongoing beach patrols have been modified to facilitate location of these animals. During the hatchling stranding season, patrols are conducted at slower speeds and patrol efforts are concentrated in areas of known, previous hatchling strandings. Public education programs, ongoing to solicit public assistance with reporting of nesting turtles and tracks, have been modified to include messages about reporting stranded hatchlings.

Figure 1. Hatchling sea turtles stranded on North Padre and Mustang Islands, Texas, 1980-1991.



# at Padre Island National Seashore

Unfortunately, in 1990, there was no suitable local facility available where the hatchlings could be taken for stabilization and rehabilitation. After coordination with John Miller (Chief, Resource Management PAIS) in early 1991, EXXON Corporation, USA donated funding for construction of a hatchling rehab facility at the park. This is the first in the world designed specifically for the rehabilitation of stranded Kemp's ridley sea turtle hatchlings. It has the capacity to hold 70 turtles, each in an individual 20 gallon aquarium. Local veterinarians assist with care of the hatchlings and those successfully rehabilitated are released into the Gulf of Mexico.

Park staff attempt to determine whether the hatchlings found washed ashore on local beaches emerged from undetected nests laid on south Texas beaches. All stranded hatchlings are measured and examined externally. Additionally, dead individuals are necropsied and gonads are removed for histological sex determination. We believe that some of the loggerhead and Kemp's ridley hatchlings found during the last decade may have emerged from nests laid on south Texas beaches. However, most of the larger Kemp's ridley and all of the hawksbill hatchlings probably originated elsewhere.

## Future Program Efforts

Since 1978, the park has been involved in a continuum of research and conservation measures to help save the Kemp's ridley from extinction. By increasing the chances of survivorship of individual Kemp's ridley turtles, park efforts ultimately may aid the overall recovery of the species.

The NPS now is focusing efforts for this species on attempts to locate and protect nesting females (wild and head-started), nests, and stranded hatchlings. Staff members at PAIS are conducting extensive beach patrol and public education programs, both of which have been given high priority in the recently completed Kemp's Ridley Sea Turtle Recovery Plan. As directed by the Recovery Plan, Endangered Species Act, NPS mandates, and PAIS Sea Turtle Management Plan, these programs will continue for the foreseeable future.

*Shaver is Supervisory Natural Resource Management Specialist at Padre Island National Seashore*

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## Mount Rainier Named A "Decade Volcano"

A science plan for organizing the research needed to evaluate the hazards associated with Mount Rainier and for developing ways to communicate this risk assessment as a basis for appropriate planning is the goal of an introductory workshop held Sept. 18-20 at the University of Washington. The workshop was organized under the auspices of the National Academy of Sciences' U.S. Geodynamics Committee in cooperation with the Academy's Board on Natural Disasters, and was co-hosted by the USGS and UWA. The University hopes to establish an interdisciplinary Volcano Studies Center.

Mount Rainier, the highest (4392m) volcano in the Cascade Range, towers over a human population of more than 2.5 million in the Seattle-Tacoma metropolitan area. Its drainage system via the Columbia River potentially impacts another half million residents of southwestern Washington and northwestern Oregon. In terms of its potential for magma-water interaction and sector collapse and for major eruptions – or debris flows even without eruption, Rainier is the most hazardous volcano in the Cascades. Although it poses significant dangers and economic threats to the region, it has received little study.

In 1989 the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) established a Task Group for the International Decade for Natural Disaster Reduction. The Task Group conceived the idea of selecting several volcanoes for focused study in the next decade as "Decade Volcano Demonstration Projects," established criteria for a "Decade Volcano," and solicited nominations. The IAVCEI accepted nominations of 7 volcanoes in developing countries and 2 in the U.S. – Mount Rainier and Mauna Loa.

Workshop organizers hope to publish the science plan by early 1993. For additional information contact Barbara Samora, Resource Management Specialist, Mount Rainier NP, Tahoma Woods, Star Route, Ashford, WA 98304-9751; (206) 569-2211.

## Toward an NPS "Virtual Library" Supporting Research Servicewide

By Diane Mallos

Forget your notion of "the library" as just a neatly organized room full of books. Instead, think of the universe of knowledge hidden away in unpublished research reports and field data as well as books, journals, manuscripts, photographs, sound recordings, video tapes, microforms, maps, data in geographic information systems, etc. Then imagine being able to find "the good stuff" or to connect with scientists in the Service or elsewhere in the world – without leaving your own park library!

NPS resources are among the most written about and studied of any in the world. More than 300 libraries in the National Park System house collections ranging in size from a few hundred to tens of thousands of volumes. In addition, most parks contain a wealth of research material that supports the park's mission. As a result, many parks contain unique collections of material that may be found nowhere else.

The current state of all this information could be said to be "available but inaccessible." The Service spends vast quantities of money on research and specialized bibliographies whose benefits are limited because of ineffective dissemination. The excellent work being done at CPSUs frequently is available only at the park or within the Region where the studies are conducted. An expensive result could be duplication of research efforts within the agency. Access to foreign research reports through such networks as Internet also could help parks avoid duplicating research done outside the Service.

Unfortunately these gold mines of resource material remain unorganized and inaccessible due to (1) lack of adequate funding and trained staff at most NPS libraries – only 4 out of the 10 NPS Regions have regional librarians, and (2) the lack of an information

network on which to share information within the NPS and internationally.

But there is hope – the hope of sharing NPS and outside research electronically – an NPS "virtual library." The great mass of knowledge held by NPS, other government agencies, and academic and research institutions worldwide could eventually be at the fingertips of NPS personnel, from scientists and resource managers to historical architects and exhibit designers – the whole array of personnel with the need to stay aware of what others are doing in the same or related fields.

The NPS Washington Office's Information and Telecommunications Division is taking this idea very seriously. In addition to setting up the technical workings of a Servicewide electronic communications network (ParkNet), they have hired a professional librarian on the Policy and Planning staff. As that new librarian, I am looking at ways to fully catalog and automate the NPS research resources now hidden in NPS libraries and other repositories.

Library software to make automation of library collections as simple and cost effective as possible is being examined. An NPS link with international networks is being investigated. Information distribution systems used by other federal agencies and various funding strategies also are being studied.

I am eager to hear from scientists, resource managers, park managers, and others regarding these issues. Please send your comments or questions to me, Diane E. Mallos, Library Coordinator, NPS Information and Telecommunications Division, Policy and Planning Staff, PO Box 37127, Washington, DC 20013-7127, or call 202/343-4430. I will be reporting further in *Park Science* as this effort develops.

# Aircraft Noise Effects Research Literature Emerging

BULK RATE  
POSTAGE AND FEES PAID  
U.S. DEPARTMENT OF THE INTERIOR  
PERMIT NO. G-83

Results of research on the effects of aircraft overflights on park resources and on visitors are becoming available as part of NPS and USFS research conducted in response to Public Law 100-91. The research is being contracted by the NPS Denver Service Center and supervised by the NPS Ranger Activities Division in Washington.

The reports include the following technical literature reviews, which may be of interest to many park areas: *Aircraft Noise Effects on Cultural Resources*; *Review of Technical Literature: Review of the Effects of Aircraft Overflights on Wildlife*; and *Effect of Aircraft Altitude Upon Sound Levels at the Ground*. Other finished reports describe methodologies for conducting noise research in parks and for surveying park visitors about aircraft noise; they also describe the noise measurement results at Grand Canyon NP and several national forest wildernesses.

Research now is being conducted to determine re-

sponses of park visitors to aircraft overflights, responses of air tour passengers, and comparison of measured noise doses to visitor responses at several parks. Computer models are being developed using NPS geographic information system technology to model the noise environment in parks and predict the effects of various mitigation strategies.

We also have our contracts structured in such a way that it is easy for anyone in the NPS to use them for consultation or research regarding any type of noise or aircraft concerns in parks.

For further information on the research, contracts, or publications, contact **Wes Henry, Washington DC, (202) 208-5211** or **Rick Ernenwein, Denver, (303) 969-2274**.

**Rick Ernenwein, NPS-DSC**  
P.O. Box 25287  
Denver, CO 80225-0287

## Regional Chief Scientists

Anderson, William H.  
NATIONAL CAPITAL REGION  
1100 Ohio Drive, S.W.  
Washington, D.C. 20242  
8 (202) 342-1443

Dottavio, Dominic  
SOUTHEAST REGION  
75 Spring St. S.W.  
Atlanta, GA 30303  
8-841-4916 (404) 331-4916

Karish, John F.  
MID ATLANTIC REGION  
Ferguson Bldg., Room 209-B  
Pennsylvania State University  
University Park, PA 16802  
8 (814) 865-7974

Kilgore, Bruce  
WESTERN REGION  
600 Harrison St., Suite 600  
San Francisco, CA 94107-1372  
8-484-3955 (415) 744-3955

Hiebert, Ron  
MIDWEST REGION  
1709 Jackson St.  
Omaha, NE 68102  
8-864-3438 (402) 221-3438

Huff, Dan  
ROCKY MOUNTAIN REGION  
P.O. Box 25827  
Denver, CO 80225  
8-327-2650 (303) 969-2650

Larson, James W.  
PACIFIC NORTHWEST REGION  
83 S. King St., Suite 212  
Seattle, WA 98104  
8-399-4176 (206) 553-4176

Foley, Mary  
NORTH ATLANTIC REGION  
15 State Street  
Boston, MA 02109  
(617) 742-3094  
FAX 617-367-8515

Kunkle, Sam  
SOUTHWEST REGION  
P.O. Box 728  
Santa Fe, NM 87501  
8-476-6870  
(505) 988-6870

Lovaas, Allan L.  
ALASKA REGION  
2525 Gambell St., Room 107  
Anchorage, AK 99503-2892  
8-869-2568 (907) 257-2568

Please address requests for information  
to appropriate Regional Chief Scientist.