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Malaspina Glacier Research Holds Clues To Possible Global Change Scenarios

By Bruce F. Molnia and John E. Jones

The Malaspina Glacier is the largest glacier in Wrangell-St. Elias National Park and Preserve (Figure 1). The glacier, with an area of more than 2,650 km², is covered by a complex system of folded moraines, the result of differences in flow rate and volume between the Malaspina's tributaries. In its lower reaches, the glacier forms a broad, bulbous, gently-sloping, piedmont lobe. The lobe, which covers an area of more than 1,500 km² is the site of an ongoing investigation by the U.S. Geological Survey (USGS), combining field observations and measurements with laboratory analysis of digital remotely sensed data.

Although the USGS has actively investigated the Malaspina Glacier and its surrounding area since the time of I.C. Russell in the 1880s, it was the November 1986 acquisition by the USGS of digital side-looking airborne radar (SLAR) data of the Malaspina Glacier (Figure 2) that resulted in the present study. The investigation has two themes: (1) the use of radar remote-sensing to provide information about the characteristics of the bedrock underlying Malaspina Glacier and the relationship of the bedrock to the glacier's surface features, and (2) the use of radar to provide information about the history of the glacier.

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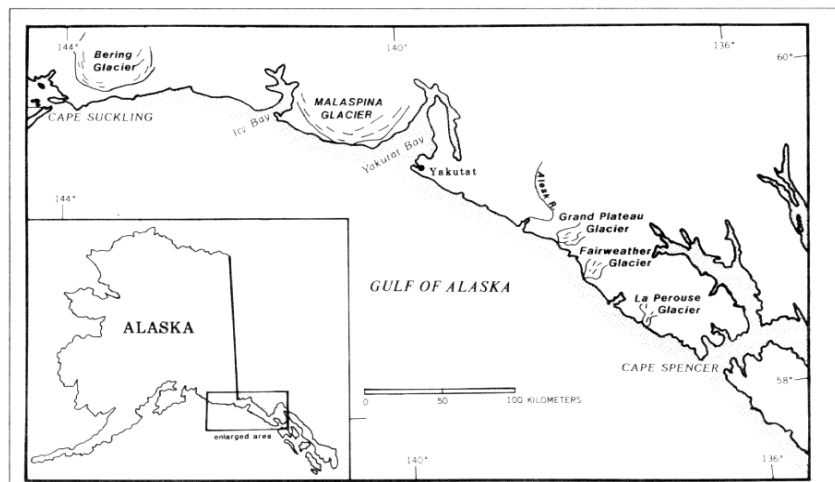


Figure 1. Map showing position of Malaspina Glacier in Wrangell-St. Elias National Park and Preserve.



Figure 2. Side-looking airborne radar (SLAR) data of the Malaspina Glacier.

ARTICLES

- Malaspina Glacier Research Holds Clues To Possible Global Change Scenarios 1
- Native Brook Trout Restoration at Great Smokies 4
- Surveys of National Park Experiences by the Visitor Services Project 5
- The Cumberland Island Cotton Mouse: A Unique Subspecies? 7
- A Sea Urchin's Response to Mass-Mortalities .. 8
- Everglades Classic Rewritten and Reissued ... 12
- Mercury Contamination: Another Threat to the Florida Panther 15
- Natural Resource Management At Colonial National Historical Park 16
- Vegetation Management in Great Basin NP ... 17
- Peregrine Falcon Research in the Yukon-Charley Rivers National Preserve, Alaska 18
- Army Chopper Rescues Falcon Counters 20
- Monitoring Case Studies Selected 21
- A Pertinent Letter from Alaska? 21
- Arctic Steppe: Snapshot of the Past or Glimpse of the Future? 22
- Effects of Global Warming on Freshwater Ecosystems 23

DEPARTMENTS

- Regional Highlights 9
- Meetings of Interest 9
- Letters 12
- Information Crossfile 13

MISCELLANEOUS

- Wilderness Proceedings 14
- ROMO Raptor Survey 20

Editorial:

Conflicting headlines scream at one another across the pages of newspapers; on radio and TV deep baritone voices, warning of impending climatic crises, compete with unctuous assurances that "nothing out of the ordinary" is going on in the global climate department. Robert C. Cowen, who writes a "research notebook" column for *The Christian Science Monitor*, examines the entire range of disputatious dialogue and winds up with this observation:

"None of this means we can ignore man-made global warming. Human activity already has added around 2.2 watts per square meter to the atmosphere's natural greenhouse heat-trapping of 151 watts per square meter of Earth's surface averaged over the entire planet and for a full year. There's little dispute about that.

"The annoying fact is that nobody yet can determine whether this has begun to raise the global temperature or merely is expressed in other effects such as undetected changes of cloudiness or ocean circulation."

Which brings Earth's human passenger complement face to face with a mathematical concept known as "type 1 - type 2 errors." A Type 1 error assumes the proposition is false when it may in fact be true. A Type 2 error assumes the proposition is true when in fact it is false. In the Type 1 error, you do nothing, assuming that no problem exists and you suffer the consequences. In the Type 2 error, you mount an effort to meet the possible problem and then it turns out there was no problem.

An examination of this concept allows us, as the deciders and also the victims of whichever error we elect to make, to examine the consequences of both errors. In the case of global climate change, we can elect the Type 1 error: Do nothing, and be unprepared in case of sea level rise, drastic alterations in whole ecosystems, fresh water shortages, entrapment of plant and animal species with no migratory corridors or plans for relocation, and so forth, all the while continuing the human behavior that may be exacerbating climate change.

Or we can elect the Type 2 error: Mount a program designed to avert global warming, engage in massive forestation and reforestation, and above all begin a globally integrated monitoring of earth, air, and water, flora and fauna, that will give us first a baseline set of data, and then a "moving picture" of how this data set is altering - where, in what directions, and how fast.

It should be obvious that the measures appropriate to the Type 2 "error" will be useful whether or not the Earth is heating up. The kinds of information such attention to the global condition will give us will be of immeasurable benefit in ANY event. It is not as though we were preparing for some terrible possibility that, if it fails to materialize, will make of all our preparations only wasted effort. The resources we spend preparing for *this* kind of threat can only add to our store of useful knowledge and help us sail into the future in a tighter, more manageable ship.

It is noteworthy that in this attempt to heal the earth many government agencies are joining hands with one another, with non-governmental entities, and with groups representing the world beyond our political borders. This summer, for instance, singer John Denver was instrumental in setting up the Aspen Institute for Global Change, co-sponsored by the Amway Corporation, the UN Environmental Program, and the National Aeronautics and Space Administration. Saving the environment, said Denver at a July 26 news conference, "is the most important task that faces the human race at this time."

Obviously Denver, Amway, the UN, and NASA have all opted to make only Type 2 errors.

The National Park Service has tailored its role in global change monitoring and research so that it fits neatly into the pattern of the national and international effort. Included in this issue is a pull-out section that presents the overall context within which the tasks will be performed and the money to do them will be allocated.

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Investigations of the Malaspina Glacier, Wrangell-St. Elias National Park and Preserve

Continued from page 1

SLAR is an electronic imaging system that has been used on a worldwide basis by the earth science community, most commonly in petroleum and mineral exploration, sea ice studies, and hydrologic investigations. SLAR data are acquired by an aircraft transmitting a radar beam perpendicular to its flight line. SLAR uses an active sensor, supplying its own source of microwave energy, allowing SLAR data to be acquired either day or night and through most cloud cover. The beam is both reflected and scattered by the ground surface and man-made objects. Energy that is bounced back (backscattered) to the aircraft's receiving antenna is recorded to produce an obliquely illuminated view of the ground, which depicts subtle aspects of surface texture, topography, roughness, slope, and wetness, and the intrinsic electrical properties of materials at or near the surface. SLAR data of the Malaspina Glacier are X-band with a wavelength of about 3.2 cm. The data were collected with a synthetic aperture radar (SAR) system and were polarized to enhance subtle horizontal features such as moraines and crevasse zones. SAR is a radar data storage and processing technology that results in improved resolution.

This study represents one of the first uses of SLAR in investigations of arctic and subarctic glaciers. The 1986 data were the first digitally acquired, airborne radar of coastal, southcentral Alaska and the Malaspina Glacier. The data showed unexpected backscatter responses from the surface of the Malaspina Glacier. Specifically, the radar imagery showed three types of features (glacial-like valleys, dendritic valleys, and an arcuate linear), that were unfamiliar to researchers working with the glacier.

Prior to field investigation of these surface backscatter features, our interpretation was that the features were real, and represented topographic differences on the glacier's surface that mimicked the morphology and relief of the bedrock that underlay Malaspina Glacier. Seismic and gravity investigations, performed in the early 1950s, determined that the ice thickness of the southeastern part of the piedmont lobe was between 500 and 1,000 m and that the bottom of the glacier extended below sea level. However, the details of the morphology of the bedrock basin underlying the glacier were unknown.

Because X-band radar doesn't penetrate more than a few centimeters of snow and ice, we reasoned that the unusual features described here were not the result of the radar "seeing through the ice," rather, they had to be surficial in nature. Consequently, we concluded that in spite of Malaspina Glacier's great ice thickness, there was some direct relationship between ice-surface morphology and underlying bedrock morphology. Understanding this relationship might help in understanding the recent and long-term histories of the Malaspina Glacier and provide insights as to how the glacier might respond to a changing environment.

As observed on X-band SLAR imagery, the three types of features have the following characteristics: GLACIER-LIKE VALLEYS are 10 to 25 km in length and about 1.5 to 2.5 km in width. These valleys are parallel or subparallel to ice flow directions. Cirque-like features, adjacent to some of the glacier-like valleys are less than 1 km across, have abrupt changes in backscatter response across their boundaries, and have rounded amphitheater-like geometries. DENDRI-

TIC VALLEYS are oblique to ice flow directions, are 6 to 12 km in length, and 0.5 to 1.0 km in width. At least 5 distinct east-west trending valleys are present. AN ARCUATE LINEAMENT, a gently curving linear feature that extends in an east-west direction for more than 65 km can be followed from the shoreline of Icy Bay, across outwash sediments and the upperpart of the Malaspina Glacier, to Malaspina Lake. The trace of the lineament may correspond to the trace of the Fairweather Fault or a related boundary fault between the North American and Pacific Plates.

The Malaspina Glacier is the largest glacier in North America and one of the largest outside the icecap regions of the world. The Malaspina Glacier was designated a National Natural Landmark on August 14, 1970. It was determined to be of national significance because of its scientific value.

Field investigations were conducted in 1988 and 1989 to "ground truth" the radar backscatter features. Specifically, investigations were conducted to determine: (1) glacier ice thickness; (2) depth to and configuration of bedrock underlying the glacier; and (3) the relationship of surface backscatter features to surface features and underlying, subglacial-bedrock morphology.

In 1988, field investigations examine the topographic relief, slope characteristics, and other surface conditions of regions of the glacier producing the three types of unusual radar backscatter features. Field work was performed in September to maximize the percent of the glacier's surface that would be snow free. The three features correspond to areas of the surface that are as much as 40 m lower than adjacent areas and are characterized by significantly fewer crevasses, minimal surface relief, a veneer of sediment, and substantially more standing and running water on their surfaces. The lows are generally areas of smooth and featureless ice and appear to be areas of compres-

sional ice flow, while the highs are areas of fractured and broken ice and appear to be areas of extensional ice flow. The ice-surface characteristics in the topographic lows would tend to attenuate or dissipate a radar signal; the result would be a weak backscatter response expressed as a dark feature on radar imagery. The topographically higher ice, adjacent to the lows, with its irregular surface, had numerous "corner reflectors", or surfaces that would provide a strong reflection of the radar signal back to the antenna. Hence, these areas have a strong backscatter and a bright appearance on radar imagery.

Ice-penetrating radar investigations conducted in September 1989 concentrated on determining the thickness of Malaspina Glacier's ice at more than 50 locations. Unlike SLAR, ice-penetrating radar, due to its much longer wavelength (many meters), can measure the depth to bedrock through a kilometer or more of ice. The maximum ice thickness measured at Malaspina Glacier exceeded 850 m, whereas the minimum was only about 150 m. Comparison of ice thickness measurements and ice surface elevations at each site suggests that the Malaspina Glacier occupies a deep basin or series of basins extending well below sea level, and that the southern limit of the glacier coincides with a large moraine complex that occupies part of the basin system. A belt of this moraine is exposed above sea level for more than 10 km at Sitkagi Bluffs and forms the rocky coastal beach that separates the glacier from the Gulf of Alaska. The basin complex underlying the Malaspina Glacier is the product of glacial erosion during a series of advance and retreat cycles extending back into the Pleistocene.

Ice thickness and elevation measurements indicate that at almost every site the base of Malaspina Glacier extends below sea level and that the ice thins significantly in the vicinity of the Sitkagi Bluffs moraine. Northeast of Sitkagi Bluffs, an ice thickness of about 175 m was measured with a basal depth only about 10 m below sea level. By comparison, at Samovar Hills,

Continued on page 4



USGS Earth Scientists, Tom Taylor (right), and Bill Schoonmaker, are seen here performing field measurements on Malaspina Glacier.

Malaspina Glacier (Continued from page 3)

approximately 50 km north of the southern limit of the Malaspina Glacier, a basin extending more than 250 m below sea level is occupied by about 860 m of ice. The maximum measured depth of the base of the ice below sea level is about 320 m.

Two measurements were made adjacent to Malaspina Lake along the southeast side of the glacier. One detected an ice thickness of about 180 m of ice extending about 75 m below sea level, and the other showed an ice thickness of about 145 m extending about 130 m below sea level.

The measurements at Malaspina Lake and Samovar Hills are very important with respect to the past and future history of the glacier. If, as a result of sea level rise, climatic warming, or coastal erosion, a portion, or all of the terminus of Malaspina Glacier were to be exposed to Gulf of Alaska marine waters, it is possible that the glacier would become an actively calving, rapidly retreating, tidewater glacier. Elsewhere, where rapid tidewater glacier retreat has occurred, such as at the Icy Bay segment of Wrangell-St. Elias National Park, Glacier Bay National Park, and Kenai Fjords National Park, fjords as long as 100 km have been exposed. At the site of the Samovar Hills measurement, even compensating for isostatic rebound, the water depth following glacier retreat would be about 125 m.

A detailed ice-penetrating radar survey with 100-m-spaced soundings was made in the southcentral part of the glacier, an area where radar backscatter features had previously been interpreted to suggest a relationship between ice surface features and underlying bedrock morphology. One transect across a surface low (channel) and its adjacent high found that whereas surface elevations only differed by about 20 m, the thickness of the ice in the area of the high was about 390 m compared to about 590 m in the adjacent low, or 200 m thicker. These data support the described relationship between surface morphology, backscatter features, and bedrock morphology.

Offshore of the Malaspina Glacier, marine seismic data document a series of sediment filled valleys cutting across the continental shelf. When projected under the large terminal moraine, the sea valleys appear to link with the glacier-valley like features seen on the SLAR data.

Several image processing and geographic information systems continue to be used in digital image analysis of the features described here. Additionally, radar data of the Alaskan coastal area from Icy Bay to Grand Plateau Glacier and for much of the southern half of Wrangell-St. Elias NP have been transferred to several CD-ROM disks that also contain public domain image processing software released by USGS and the National Space and Aeronautics Administration.

Field work, including additional ice-penetrating radar studies planned for 1990 through 1993, will continue to carefully measure ice thicknesses and the bedrock morphology underlying Malaspina Glacier and several other glaciers in southern Alaska. With these data in hand, we will have a much more complete understanding of the relationship between ice surface morphology and the topography and morphology of the underlying bedrock. We will also have a much better understanding of the ability of SLAR to provide information about the past and future histories of the Malaspina Glacier system.

Molnia and Jones are research scientists with the U.S. Geological Survey at Reston, VA 22092.

Native Brook Trout Restoration at Great Smokies

Distribution of native brook trout (*Salvelinus fontinalis*) in the Southeast has undergone major shrinkage since 1900 (Seehorn, 1978). One of the best documentations of this decline is in Great Smoky Mountains NP (GRSM), and an excellent, detailed report of attempts there to eradicate the non-native rainbow trout from native brook trout streams appears in the *Proceedings* of the Wild Trout IV Symposium held at Yellowstone NP Sept. 18-19, 1989.

The paper, by Stephen E. Moore and Gary L. Larson, describes how, prior to establishment of the park in 1936, the area was extensively logged and brook trout disappeared from downstream segments of many streams in logged watersheds (Powers 1929). Rainbow trout (*Oncorhynchus mykiss*) were introduced into these stream segments and into other streams inhabited by brook trout beginning about 1910

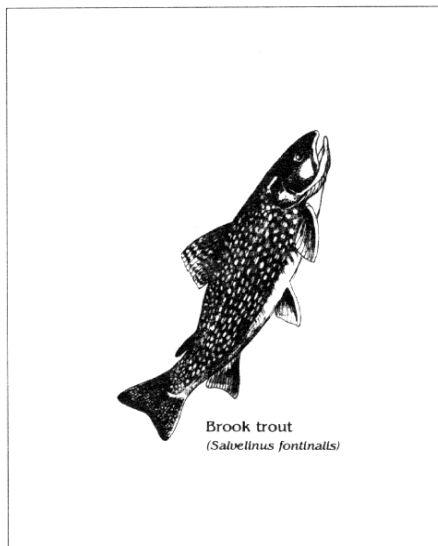
poorly understood, (Larson and Moore, 1985) the results of the extensive testing described in the article seem to demonstrate clearly that rainbow trout have a negative effect on native brook trout.

Initial restoration work by Moore et al. (1983, 1986) did not appear to eradicate rainbow trout. These results did show that the density of adult rainbow trout was reduced to less than 1/100 m² in one field trip (consisting of 3 electrofishing passes) in some streams, but additional effort was required in others. This variation in success was due to the complexity of the stream channels, which affected the efficiency of the electrofishing. Nonetheless, the results indicate the backpack electrofishing technique can be used to control density of rainbow trout. In fact, eradication is feasible in small streams.

Reclamation by electrofishing is labor-intensive and time-consuming (Moore et al. 1983). A 2-person crew expends about 1-person day fishing a 100-m section of stream 3 times. Use of large crews and multiple shocking units increases capture rate, but does not appear to reduce labor costs. (Larson et al. 1986).

The experience Moore and Larson report with the backpack electrofishing technique suggests that several precautions should be considered before undertaking a restoration project. First, streams must be on an appropriate size to make the effort worthwhile. If large streams are targeted for restoration then other techniques should be explored. Second, the project should be adequately funded because several years of effort may be required to control non-native fish populations. Third, the targeted restoration area should be upstream from a known barrier to fish immigration, otherwise non-native fish may immigrate upstream into the restored section.

Moore is a fisheries biologist at Great Smoky Mountains NP; Larson is an aquatic ecologist with the NPS/CPSU at Oregon State University.



Vern Hippensteel's artwork, from *Protecting Biological Diversity in the National Parks* (see mention in *Southeast Regional Highlights*).

(King 1937). Park management later supplemented these stockings from rearing facilities in the park to provide recreational angling.

The general view was that brook trout would recover its former range as the forests recovered. But early work by King (1937) suggested that rainbow trout populations were expanding into brook trout waters, thereby further reducing the distribution of brook trout. Although surveys in the 1950s (Lennon 1967) did not show much change in brook trout distribution relative to King's initial observations, later surveys by Jones (1978) and Kelly et al. (1980) clearly demonstrated a substantial decline.

The gravity of the problem prompted NPS to initiate a series of studies between 1975 and 1981 to evaluate rainbow trout encroachment into brook trout streams and to determine the feasibility of eradicating rainbow trout from selected isolated streams, using the backpack electrofishing technique. Moore's and Larson's paper summarizes the results of these studies and reports on a recent investigation that evaluated success of the restoration program.

Although the encroachment process is difficult to document due to complex and dynamic abiotic and biotic interactions, and although the mechanisms are

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Surveys of National Park Experiences by the Visitor Services Project

By Dana Dolsen

The Visitor Services Project (VSP) conducts surveys to gather information about visitors and visitor services that park managers can easily use. At least three kinds of sociological information are useful to park managers. The first is knowledge about the kinds of services, activities and opportunities available to the public. The second is knowledge about the visitors: who they are, where they go, what they do, and so forth. The third is understanding the relationship between services and visitors; i.e., are visitor needs being met in the most efficient way, while protecting resources?

The VSP is based at the University of Idaho's Cooperative Park Studies Unit (UI/CPSU) in Moscow, Idaho. The VSP's technical development began with pilot studies in 1982. Figure 1 shows that by the end of 1990, 37 visitor studies will be completed in 34 parks. In 1988 the VSP was incorporated into NPS Operations. Currently two NPS employees are stationed at the UI/CPSU: Margaret Littlejohn is western coordinator, Dwight Madison is eastern coordinator.

The Chief of Interpretation, Washington Office (WASO), holds VSP administrative responsibility. VSP study funding comes from the park being studied, regional offices, and WASO. The VSP has an advisory committee; its membership provides Service-wide guidance from parks, regional offices, and Service Centers. The committee meets annually, recommends parks for studies from regional nominations, guides VSP development, and approves special projects.

Study Process and Methods

Figure 2 presents the VSP study process. After a park's selection, VSP personnel hold an on-site questionnaire design workshop to determine the park's information needs about its visitors. In the field a trained team contacts visitors, conducts interviews, and distributes mail-back questionnaires. Completed questionnaires are received at the UI/CPSU; data definition, input, verification, and analysis are completed. A draft report is prepared, reviewed by park staff, and revised by the VSP. A results workshop on how the data can be used is held for each park's staff. Sometimes a separate session is held for local media, the chamber of commerce, and others. The final report is then printed and made available from the superintendent. For the next six months, upon request, additional data analyses are provided to the park at no additional cost. In 1989, the average cost to parks was approximately ten thousand dollars.

VSP visitor studies are based on a systematic sample of park visitors during a specific week chosen by park staff. The sample is usually stratified by entrance or zone, depending on park characteristics. Sample size is based upon past visitor statistics, with a minimum accuracy of ± 4 percent for simple dichotomous variables at the .05 level. The VSP and park staffs jointly formulate the appropriate questions, which must then be approved by the Office of Management and Budget (OMB). A core unit of standardized questions is in most VSP studies (i.e., demographics, use of routes/sites, activities, and general comments); OMB approval of these is commonplace. New questions on unique park issues need specific OMB clearance.

As visitors enter the area, interviews are conducted to distribute the mail-back questionnaire, collect data

1982	1983	1984	1985	1986	1987	1988	1989	1990
	Development Studies			Operational Studies				Studies Underway
Grand Teton	Yellowstone	Glacier	Crater Lake	Gettysburg	Harpers Ferry	Craters of the Moon	Everglades	Death Valley
	Mt. Rushmore				Grand Teton		Statue of Liberty	Glacier
			North Cascades	Independence	Yellowstone	Bryce Canyon	Delaware Water Gap	White Sands
				Valley Forge	Mesa Verde	Glen Canyon	Lincoln Home	Kenai Fjords
					Independence	Denali	Yellowstone	John Day Fossil Beds
					Colonial		Muir Woods	Canyonlands
					Shenandoah		White House	National Capitol Region-Mall
								Petersburg
								Gateway
								Scotts Bluff/Agate Fossil Beds

Figure 1: VISITOR SERVICES PROJECT 1982-90

Figure 1. Visitor Services Project 1982-90.

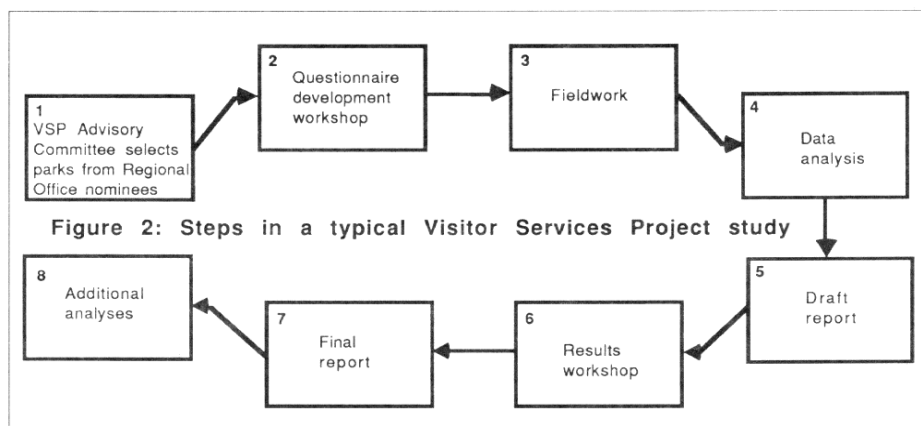


Figure 2. Steps in a typical Visitor Services Project study.

for response bias checks, and gain mailing addresses for follow-ups. The 11 studies conducted in 1988-89 have averaged an 81 percent response rate. Response bias checks on key demographic variables are conducted; the data are converted into graphic displays. Charts and figures with low sample sizes are identified with cautions for managers to consider. Open-ended questions are content-analyzed and organized into tables, and the actual comments included in a separate appendix to the final report.

The surveys have several limitations, described in each final report. Responses to mail-back questionnaires may not always reflect actual behavior. The results cannot be generalized beyond the study period. Visitor groups that do not include an English-speaking person may be under-represented.

Following are examples of what parks learned from visitors about services and facilities offered, plus visitor opinions on topics of interest to park managers.

STUDY RESULTS, MANAGEMENT IMPLICATIONS

Interpretation

Managers question whether interpretive programs meet real needs. Do they effect changes in visitor awareness, attitudes, or even behavior? Tour managers at the White House may question whether separate tour needs for programs and services exist by

comparing their Congressional and public tour results. For example, public tour visitor groups used the map/brochure twice as much as did Congressional tour visitor groups (see Figure 3). To ensure its continued use and usefulness for each tour, a detailed evaluation may be desired.

Concessions

Park managers question how useful and important particular services or facilities are to visitors; VSP surveys can provide such data. A park can then evaluate a company and the need for a product or service.

Managers at the Statue of Liberty NM measured visitor use of several concession services/facilities, as well as their quality ratings. Figure 4 shows that visitor opinions varied on the quality of the restaurant. Potentially, a variety of alternatives to improve quality may be considered.

Maintenance

Increasingly diverse park visitors demand a range of accessible, quality facilities. Visitors frequently criticize trash build-up or a lack of upkeep at park sites. By seeking and listening to visitors' views, managers can improve facility maintenance programs, thus providing clean and well-maintained settings for quality experiences.

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Visitor Services (Cont. from p. 5)

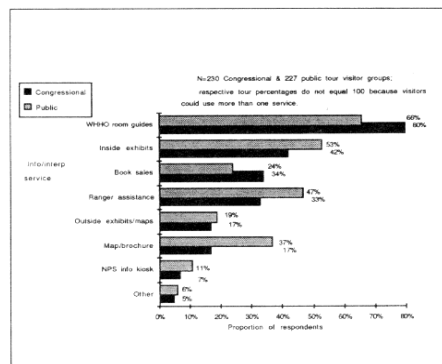


Figure 3. Congressional and public tour use of White House interpretive/information services, Summer, 1989.

For example, Muir Woods NM's trails are congested in the summer. Managers could schedule maintenance personnel on popular trails according to the proportion of visitors (see Map 1), peak hours, or busiest days.

Resource Management

Determining ecologically appropriate and socially acceptable levels of intervention in natural processes is a constant challenge and struggle for land management agencies. The NPS is learning that people do not have a basic understanding of natural phenomena, which in turn affects the acceptance of resource management policies. Land managers may gain policy insights for the future by assessing visitors' perceptions of natural and man-made phenomena and their impacts.

For example, Yellowstone NP visitors were asked if the 1988 fires were beneficial to Yellowstone's natural systems (plants, animals, soil, water, etc.). Figure 5 shows that 48 percent of visitors thought fire benefitted Yellowstone's ecosystem. Such results could help all land management agencies make more informed policy decisions.

OTHER PROJECT UPDATES

Projects underway include: a report on 1982-90 VSP progress – *A Diversity of Visitors*, a VSP training manual, an OMB report on survey follow-up methods, and several journal articles. The Pacific Northwest Regional Office funded a 1989 VSP database development to profile NPS visitors; data may be available from approximately 20 park studies by the end of 1990.

FUTURE DIRECTIONS AND INITIATIVES

The database will provide information on park visi-

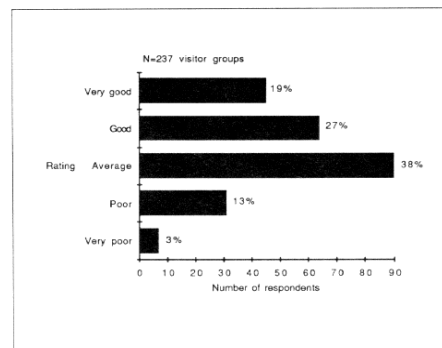


Figure 4. Visitor quality ratings of restaurant, Statue of Liberty NM, 1989.

tors studied nationwide and, possibly, data sets of each park's seasonal visitor information. For example, Map 2 shows the proportion of first-time visitors to various parks throughout the national park system. A large database will accrue, as 10-15 park studies could be added early.

The VSP is developing the capability to provide data on the economic contribution (i.e., jobs supported, sales and income generated) of park visitors during the study. Initial efforts began with an economic impact analysis of visitation to Lincoln Home NHS using IMPLAN, a computer modelling system developed by the U.S. Forest Service.

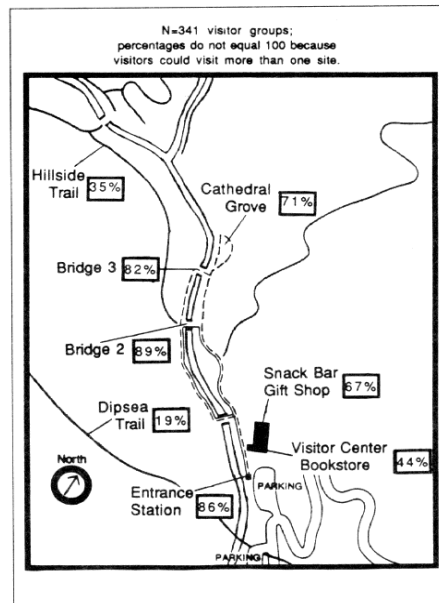
The VSP initiative is an interdisciplinary tool that can help the NPS constantly improve managerial efficiency and applicability. For example, visitors touring the White House strongly confirmed the need for a visitor center. Similarly, visitors to Lincoln Home NHS endorsed a new combination of first-come, first-served and advance reservations for tour tickets. And Denali NP was able to show support for the shuttle bus system because the service enabled a high proportion of users to view key wildlife species.

Through systematic baseline surveys of visitors, such as those conducted by the VSP, new management strategies may be developed. The potential for the consistent application of these data to a broad range of park management issues shows that visitors' views are important and beneficial.

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Map 1. Proportion of visitor groups visiting each site, Muir Woods NM, 1989.

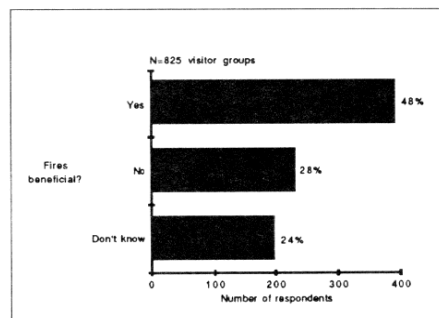
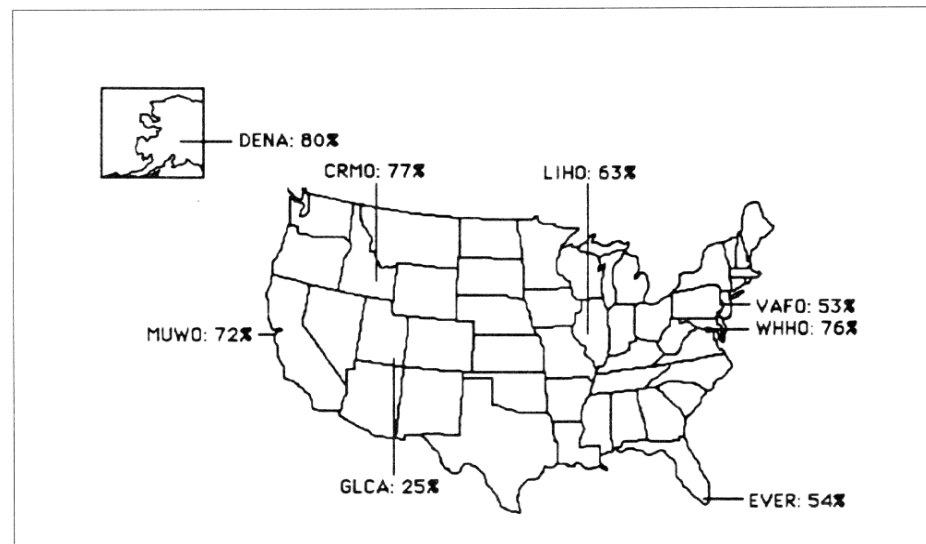


Figure 5. Proportion of visitors who viewed fire as beneficial to natural systems, Yellowstone NP, 1989.

Project Report 25: Yellowstone National Park. Moscow, ID: UI CPSU.

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Map 2. Proportion of first time visitors to various parks, VSP studies, 1986-89.

The Cumberland Island Cotton Mouse: A Unique Subspecies?

By James L. Boone, Joshua Laerm, and Michael H. Smith

The systematics of rare species often is problematic and may lead to the conservation and management of apparently rare organisms which are not truly rare (e.g. dusky seaside sparrow, Avise and Nelson, 1989; colonial pocket gopher, Laerm et al., 1982). Alternatively, inattention to the systematics of even common organisms may lead to the lack of concern for unique populations, subspecies, or even species that have not yet been identified. The cotton mouse (*Peromyscus gossypinus anastasae*), occurring only on Cumberland Island National Seashore, GA, is an example of an apparently rare organism that has generated management concern. This population was considered the only extant representative of its subspecies, and therefore should have qualified for rare and endangered status. However, it never was listed because of questions concerning the validity of its taxonomic status.

This mouse originally was described in 1898 as *P. insulanus*, a distinct species, based on its small size and light colored pelage. Osgood (1909) reduced the species to a subspecies of *P. gossypinus* and classified it with the population of mice on Anastasia Island, FL as *P. g. anastasae*. The Florida population was considered for state and federal protection in the 1970s, but because of uncertain taxonomy, its status was listed as uncertain. The Florida population again was considered for federal protection in the mid-1980s, but it was found to be extinct, and the subspecies was declared UR-3 (no longer under consideration for listing due to the pervasive evidence of extinction.)

Although there were no data, federal officials stated they did not believe the Cumberland Island population was referable to *P. g. anastasae*. However, in the scientific literature, the extinction of the Anastasia population leaves Cumberland Island with the only extant population of *P. g. anastasae*. The subspecific status of this mouse was questioned by Osgood himself, but no systematic assessment had been conducted since his study. Recently, Boone (1990) reviewed the taxonomic

affinities of the cotton mouse population on Cumberland Island to determine if this population was unique and if it deserved management and protection.

Populations representing 4 subspecies of cotton mice from throughout Georgia, Florida, and Alabama were examined. Genetic analysis involved electrophoresis of the products of 44 loci in 379 mice from 14 populations, including 6 insular populations. (Figure 1). Morphological analysis involved examination of 27, mainly cranial, characters of 683 specimens from 20 populations, including the extinct Anastasia Island population.

Genetically, this species is highly variable both within and between populations. The percentage of polymorphic loci and heterozygosity per population is quite high, and their heterozygosity is twice the average reported for mammals. There is no evidence for inbreeding, drift, or founder effects reducing genetic variability on the islands despite large fluctuations in the numbers of mice on the islands. If migration between the mainland and the islands occurs, it appears to be limited, so the mechanism for maintaining genetic variability on the islands is unclear. Genetic distances among populations (Rogers, 1972) are relatively high for conspecific populations of mammals, and are comparable to the genetic differences among some *Peromyscus* species. As a group, the insular populations tended to have a greater degree of genetic differentiation than did the mainland populations.

Using genetic variance partitioning (Fst analysis) with the genetic data and discriminant analysis with the morphological data, essentially every population is significantly different from all others when tested in pairwise comparisons. Mice on Cumberland Island are genetically and morphologically significantly different from those on the mainland opposite Cumberland, and significantly different from these on the islands immediately north and south of Cumberland. If only these populations had been sampled, the Cumberland population probably would have retained its subspecific status. However, when all populations were examined simultaneously, the pairwise interpopulation differences became trivial and were not significant ($p > 0.05$), as shown in Figure 2 for the morphological data. While each population was genetically and morphologically unique, no population was unusually distinct, and neither the Cumberland Island nor Anastasia Island populations of *P. g. anastasae* was sufficiently different from other populations to warrant recognition as a separate subspecies. Thus, there is no basis to support the subspecific status of *P. g. anastasae*, and these mice should be designated *P. g. gossypinus*, the common mainland species.

Removing subspecific status from the mice on Cumberland Island, *P. g. anastasae*, and grouping them with *P. g. gossypinus*, does not imply that the Cumberland Island mice are genetically or morphologically identical to any other population or subspecies of *P. gossypinus*. Genetically, the Cumberland Island mice are unique and are well differentiated from other populations. For example, they have 5 alleles not found in any other population, and therefore represent a genetic resource that deserves conservation.

Other biota on the islands also will probably be found to be genetically differentiated. Rowland (1989) found

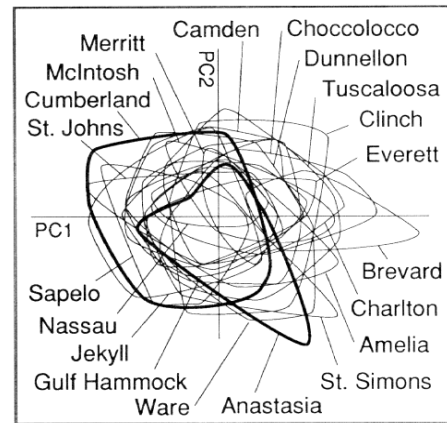


Figure 2. Distributions of 20 populations of *Peromyscus gossypinus* on the first two principal component axes extracted from the covariance matrix constructed with data from 27 morphological characters.

the white-tail deer (*Odocoileus virginianus*) on Cumberland Island to be genetically significantly different from deer on the mainland, and deer on Black Bear Island just north of Sapelo are genetically the most divergent of any white-tail deer population studied in various parts of the southeastern United States (Hillestad, 1984). These deer populations tend to have relatively high frequencies of rare alleles similar to the situation in the Cumberland mice. Thus, even if the islands do not provide habitat for any known unique subspecies, if our goal is to conserve biological diversity, then conservation of biota on these islands is particularly important because in many cases this biota contains the most genetically divergent populations in the species.

This study was supported by the NPS/CPSU at U/GA, the U/GA Museum of Natural History, and Savannah River Ecology Laboratory under contract between the US Dept. of Energy and U/GAs Institute of Ecology. Final reports concerning the taxonomy and conservation of this mouse will be submitted for publication elsewhere.

Boone is with the U/GA School of Forest Resources and Laerm is with the U/GA Museum of Natural History, Athens, GA; Smith is with the Savannah River Ecology Lab, Aiken, SC.

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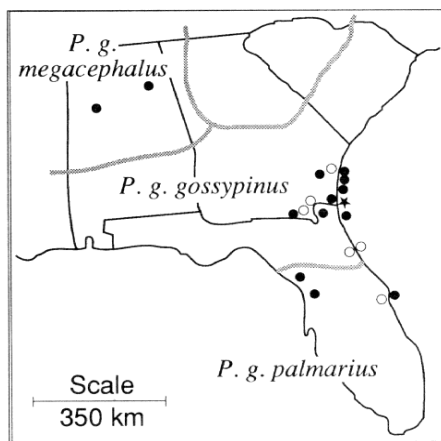


Figure 1. Southeastern United States showing locations (black symbols) from which specimens of 4 recognized subspecies of *Peromyscus gossypinus* were collected. Gray lines indicate subspecies boundaries, Cumberland Island is indicated with a star, and unfilled symbols indicate sites from which genetic data were collected.

A Sea Urchin's Response to Mass-Mortalities

By Don R. Levitan

The tropical black sea urchin *Diadema antillarum* is well known in the Caribbean for its long and poisonous spines. Before 1983, it was abundant and had a profound influence on coral reef communities. This urchin grazed up to 20 percent of the reefs primary productivity (Hawkins and Lewis 1982), bioeroded large areas of the reef (Stern and Scoffin 1977), competed with herbivorous fish (Hay and Taylor 1985, Carpenter 1986), and influenced the successful settlement and survivorship of corals (Sammarco 1982). *Diadema* is an extremely influential species in the Caribbean.

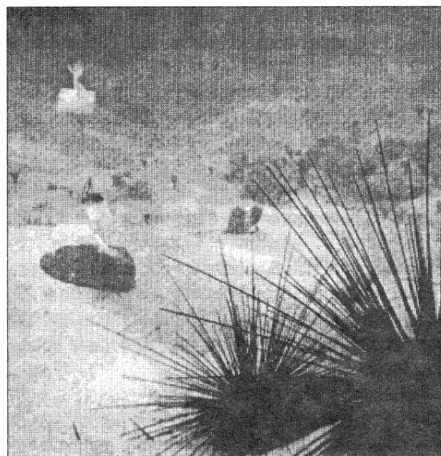
During 1983-84, a mass-mortality, due to an unknown pathogen, destroyed 99 percent of this species throughout the Caribbean (Lessios et al. 1984). With the help of the NPS in U.S. Virgin Islands, I have been investigating the population ecology of *Diadema* in an attempt to understand the dynamics which led up to and followed this unprecedented mortality event.

In the summer of 1983 (6 mo. prior to the mass-mortality), a census program was started on St. John, U.S. V.I. This monitoring effort indicated that *Diadema* exhibited an inverse relationship between body size and population density (Levitan 1988a). Laboratory and field experiments documented that this relationship was due to individual sea urchins adjusting body size by growing or shrinking based on food availability. Urchins growing or shrinking to a food- or density-dependent body size were not significantly different in measurements of test diameter, weight, gonad volume, or survivorship (Levitan, 1989a). Further experiments indicated that migration out of food-limited conditions on the reef was found to be disadvantageous, since predation pressure off the reef was significantly higher than on the reef (Levitan and Genovese, 1989).

These results may provide insight as to the rapid spread and magnitude of the mass-mortality. Increased population density, through planktonic settlement, results in reduced body size and not increased mortality (Levitan 1989a). Without density-dependent population regulation, population size increases unchecked. Previous to the mass-mortality this urchin was extremely abundant (i.e., 72/m² in Jamaica: Sammarco 1982). High population density may have facilitated the spread of the water-borne pathogen, by increasing the probability of urchin to urchin transmission (Lessios 1988, Levitan 1989a).

The monitoring program has continued on St. John, following the response of the surviving urchin population and its algal resource. By the summer of 1984 (6 mo. after the mass-mortality), urchin abundance had dropped from 15/m² to less than 0.1/m². The urchins resource, benthic algae, increased 3000 percent in biomass (Levitan 1988b). Since 1984, the surviving *Diadema* have increased in size dramatically. At present (June 1990), median urchin weight is over 300 g; an order of magnitude greater than the median weight of 20 g, previous to the mass-mortality (Levitan 1988b). Population density has not increased since 1984. Predictions suggested that this urchin would rapidly return to former abundances, since individuals were growing rapidly and producing large quantities of gametes. There are two probable reasons for the lack of juvenile recruitment.

The first reason involves the reproductive biology of *Diadema*. Sea urchins, like many marine invertebrates, release unfertilized eggs and sperm into the water. In order to guarantee a high rate of fertilization,



males and females must release gametes in close proximity to one another (Pennington 1985, Levitan 1989b). Following the mass-mortality, population density has been too low to insure fertilization success. Field experiments on St. John indicate that although urchins are now much larger and producing more gametes than before the mass-mortality, fertilization rates are so low that very few larvae are being produced (Levitan 1988c, 1989b).

The second reason for poor recruitment involves the scale of the mass-mortality. This event was widespread, affecting all Caribbean populations. If the event was local, other source populations could have restocked St. John; larval *Diadema* spend from 8 to 12 weeks in the plankton before settling (Carpenter personal communication). At present, the only known source population is in the Canary Islands, in the Eastern Atlantic (Lessios 1988). The only Caribbean island receiving substantial recruitment is Barbados, the eastern most Caribbean island (Hunte and Younglao, in press). It may be that larvae are traveling across the Atlantic and settling on Barbados (Carpenter personal communication). The high recruitment could also be due to island eddies keeping larvae produced at Barbados nearby, rather than dispersing them away (Hunte and Younglao, in press). If *Diadema* populations on Barbados can return to high enough densities, it may have a downstream cascading effect which could repopulate the rest of the Caribbean (Levitan 1989).

During the past year hurricane Hugo struck the Virgin Islands killing large numbers of *Diadema*. Adult population density declined almost an order of magnitude in many of the census sites. Fortunately, large numbers of urchins settled on St. John since the storm. Populations at such low numbers should be monitored carefully since the probability of local extinction is relatively high.

In any event, *Diadema antillarum* will not return to former densities for several decades, if at all. Since this species has a major influence on many reef processes, this suggests that Caribbean reefs will remain changed as well.

Levitan is a post-doc researcher at the Banfield Marine Station, Univ. of Alberta; this work was part of his doctorate in Biol. Sci. at U/Del.

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Director's Awards

Francis Singer, Research Ecologist at Yellowstone NP, and David Haskell, Chief of the Resources and Science Division at Shenandoah NP, are the recipients of the second annual Science and Natural Resource Management awards, instituted in 1989 by NPS Director James M. Ridenour.

Singer is being honored for research contributions to natural resource management issues at Yellowstone, particularly his ungulate work. He has conducted, supervised, and directed significant research on the ungulate prey base for potential reintroduction of the gray wolf at Yellowstone, elk winter kills after the 1988 Yellowstone fire, and effects of native ungulate browsing on Yellowstone's northern range.

Haskell is recognized for his leadership in a 6-year effort to implement a long-term environmental monitoring program at Shenandoah. He has obtained continued park and regional management and fiscal support, worked effectively with university scientists to design the program, hired high quality staff, and integrated his staff and program into park operations for long-term program viability.

The awards were scheduled for formal presentation at the September Regional Directors' meeting.

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Southeast Region

Protecting Biological Diversity in the National Parks: Workshop Recommendations, Transaction and Proceedings Series #9, is a handsomely illustrated 80-page account of the May 1988 workshop held at Great Smoky Mountains NP. Editors were Dominic Dottavio, Peter F. Brussard and John McCrone. Vern Nippensteal's pen and ink drawings on the cover and in the text depict important examples of the rich biological diversity native to the Great Smokies and the surrounding southern Appalachians. Copies are available from Donna O'Leary, NPS Publications Coordinator, c/o Air Quality Division, PO Box 25287, Denver, CO 80225.

Everglades NP has received additional funding for an exotic plant control program in the East Everglades Area (soon to be acquired as part of the park). The funding (\$792,000) is a result of the mitigation requirements by the State Department of Environmental Regulation for the State Department of Corrections to build additional correction facilities.

Beginning in 1990, the South Florida Water Management District will also provide \$60,000 each year for the next 3 years of the project as part of overall funding (\$1,500,000) for exotic control in South Florida. These funds augment an already existing interagency fund supported by Dade County Department of Environmental Resource Management (mitigation funds), the State Department of Environmental Regulation (grant requests from the "Pollution Recovery Act") and Everglades NP. As a result of past work and planned work using new funding, we will have successfully controlled over 3 million exotic trees covering over 75,000 acres of quality wetlands.

The Southeast Region has established three new divisions in the Office of Science and Resource Management: (1) Coastal and Marine Ecosystem Research; (2) Terrestrial Ecosystem Research, and (3) Natural Resource Management and Policy. The ecosystem research approach is to develop information for the management of ecosystems and environmental concerns that are multi-park in scope. Research and research administration positions are being established that will be attached to academic institutions to develop specific elements of the ecosystem research programs and to assist in developing I&M, data management, and GIS programs.

Cooperating in educational efforts related to park problems is part of the mission of CPSUs, and for the past two years, at the U/TN CPSU, Dr. Stephen Nodvin has organized a seminar course on Environmental Impacts to Natural Ecosystems. This year Nodvin will assist in presenting an Introductory Course on Forest Soils and Watershed Management. He will be part of a team of scientists, cooperating to offer the course while the shoes of retiring Prof. Frank Woods are being filled. Major topics of forest soils and watershed management will be covered by Helga van Miegroet (Oak Ridge National Lab) and Jim Patrick (USFS-retired). Nodvin will handle ecosystem and park-related issues.

When Mrs. Marion E. Bailey of Largo, FL, died on Nov. 17, 1988, she bequeathed nearly \$130,000 to the NPS "for the purpose of preserving and benefitting wildlife." Even as significant an amount as \$130,000 would have disappeared in time had it been used for direct funding of individual wildlife management or

research activities. A suggestion was made to create an endowment fund to support wildlife-related graduate research in NPS areas in the Southeast. Requests for proposals went to five universities in the southeast having graduate wildlife programs. The Clemson University proposal, which offered as much as a 3-1 ratio of matching funds, was selected. A cooperative agreement now is being established for administration of the Marion E. Bailey Scholarship Fund for Wildlife Research in the National Parks of the Southeast Region.

A cooperative agreement was signed recently with The Nature Conservancy to systematically search for and compile existing information on plants and animals of special concern to parks in south Florida and the Caribbean, with emphasis on coral reefs and marine ecosystems. Project costs will be shared equally by NPS and TNC. The information collected will be stored in the South Florida/Caribbean Natural Heritage Data Center housed at Everglades NP. The Data Center is part of the nationwide network of Natural Heritage Program databases.

In another cooperative project, the Southeast Regional Office worked with TNC to develop a proposal for using the Natural Heritage Program network to share biodiversity information across parks, regional offices, and WASO. Funding was provided for a pilot project linking the Mid-Atlantic and Southeast Regions with WASO.

A major evaluation of several proposed water delivery schedules for Everglades NP was produced by the staff at the NPS South Florida Research Center. The 99-pages report, plus appendices, recommends a "Basic Rain-Driven" water delivery schedule, along with major structural changes in the delivery system, as the best plan for reestablishing more natural hydrological species in the southern Everglades. In response to recent controversy regarding ecosystem vs. endangered species approaches to Everglades management, the SFRC report (edited by R.A. Johnson and J.C. Ogden) demonstrates why the ecosystem approach will also be most beneficial to the principal

Continued on page 10

meetings of interest

1990

Oct. 13-19, NATURAL AREAS/YOSEMITE CENTENNIAL SYMPOSIUM, at Yosemite NP and the San Francisco Bay area; jointly sponsored by the Park and the Natural Areas Assn., "Natural Areas and Yosemite: Prospects for the Future;" contact: Coordinator, Natural Areas/Yosemite Symposium, GGNRA, Fort Mason Bldg., #201, San Francisco, CA 94123; (415) 556-1009; FAX (415) 556-1399.

Nov. 12-15, RESOURCE TECHNOLOGY 90, Second International Symposium on Advanced Technology in Natural Resource Management; at Georgetown University Conference Center, Washington, DC. Contact Resource Technology 90, 2625 Redwing Road, Drake Executive Plaza, Suite 120, Fort Collins, CO 80526-2878; (303) 226-1688; FAX (303) 226-1688.

Nov. 12-17, SIXTH CONFERENCE ON RESEARCH IN THE NATIONAL PARKS AND EQUIVALENT RESERVES, at the Westin Paso del Norte Hotel, El Paso, TX; Contact: Conference Committee at (415) 556-1866.

Nov. 27-29, NEW PERSPECTIVES FOR WATERSHED MANAGEMENT; Balancing Long-Term Sustainability With Cumulative Environmental Change, sponsored by U/WA Center for Streamside Studies and OR/St/U Col. of Forestry, at U/WA, Seattle. Contact: Continuing Education, Coll. of Forest Resources, AR-10, U/WA, Seattle, WA 98195 (206) 543-0867.

1991

May 14-19, INTERNATIONAL CONFERENCE ON SCIENCE AND THE MANAGEMENT OF PROTECTED AREAS, at Acadia University, Wolfville, N.S. Canada. To serve as a forum for examining current perspectives on the role of science in managing protected areas and the role of protected areas in the conduct, support and promotion of scientific research, and as a lead-up to the IUCN World Parks Conference, 1992. Contact Neil Munro, Director, Policy Planning & Research, Canadian Parks Service, Atlantic Region, Environment Canada, Historic Properties, Halifax, Nova Scotia, Canada, B3J1S9.

May 19-23, THIRD ANNUAL SOCIETY FOR ECOLOGICAL RESTORATION CONFERENCE, in Orlando, FL. Contact SER, 1207 Seminole Highway, Madison, WI 53711; (608) 262-9547.

October (no date given in initial announcement), SOCIAL ASPECTS AND RECREATION RESEARCH SYMPOSIUM, Theme, "The Wildland/Urban Interface," at Lake Tahoe, interfacing resource managers and scientists in small group discussions of research findings. Sponsored by USFS, BLM, Society of American Foresters and others. For information write Debbie Chavez, SARR Symposium Coordinator, USDA Forest Service, 4955 Canyon Crest Drive, Riverside, CA 92507.

Nov. 4-8, THIRD GLOBAL CONGRESS OF HERITAGE INTERPRETATION INTERNATIONAL, in Honolulu, to explore how effective interpretation can help protect natural and cultural heritage while providing meaningful and memorable experiences for residents and visitors. Contact: Gabriel Cherem, EMU Geography & Biology, Ypsilanti, MI 48197; (313) 487-0218, or Ray Tabata, UH Sea Grant, (808) 948-3191.

Southeast Region (Continued)

endangered species (Wood Stork, Snail Kite) potentially affected by the restoration program.

David Moon, hydrologist, is finishing set-up of an enhanced hydrologic network to monitor water levels and rainfall in the Shark River Slough, Everglades NP. Data collection over the next two years will allow for assessment of long-term hydrologic monitoring needs and provide data necessary for hydrologic restoration options. A project methodology report will be published this winter.

Midwest Region

The St. Croix National Scenic Riverway brought out the divers and waders of the USFWS, the Wisconsin Dept. of Natural Resources, and its own staff to check on the status of the federally proposed-for-listing winged Mapleleaf mussel (*Quadrula fragosa*). Known only from a 5-mile stretch of the St. Croix River below a hydroelectric facility, the population beds may have been severely impacted by de-watering and freezing temperatures during the winter of 1989-90. Preliminary results were not encouraging; only a few individuals were found. Further monitoring continued during the late summer low water period.

Pipestone National Monument was chosen by the Minn. Dept. of Natural Resources as one of the 5 host sites for the Minnesota Prairie Heritage Day, held on Aug. 11, 1990. This was the fourth annual celebration of Prairie Day in Minnesota. The day is designed to focus attention on the less than 1 percent remaining of original prairie, which once consisted of nearly 18 million acres. Pipestone NM was designated as a Natural Heritage Area in Minnesota in 1983.

A detailed vegetation map of Pipestone NM, produced through a GIS at the University of Nebraska-Lincoln, will help park staff better manage the cultural and natural resources of the monument. Using ARC/INFO software, a GIS is being developed for Pipestone. To make the GIS possible, 12 to 14 digitized map layers must be produced, depicting factors that affect vegetation type and distribution (e.g. slope, drainage, elevation, soil type, historic land-use changes and old fence lines). Similar projects are slated for Wilson's Creek National Battlefield in Missouri and Scotts Bluff National Monument in Nebraska.

For the third year, biologists from three land management agencies, a local university, a national conservation group, and key members of the public met at Pictured Rocks National Lakeshore to discuss coordinated efforts toward protection and recovery of the federally listed (endangered) piping plover (*Charadrius melodus*). Federal and state agencies have essentially no land holdings within critical plover nesting areas. Protection efforts thus rely almost entirely upon local governments and private citizens. The information that was generated at the third annual meeting has led some resort owners who possess critical beach habitat to take a strong interest in the plover. The Michigan Dept. of Natural Resources has provided funds for annual monitoring and local governments have prohibited over the road vehicles on critical beach habitat. NPS cannot afford to operate on the assumption that its boundaries have biological meaning.

Mid-Atlantic

Chief Scientist John Karish reports availability of a report by Julie Downs and Marc Abrams of PA/St/U titled *Friendship Hill National Historic Site Vegetation Study* (Tech Rpt. NPS/MAR/NRTR-90/045). Notable findings include detailed sampling data from an old-growth oak forest where over 90 percent of the trees are greater than 120 years old, some over 300.

A Social Science Research plan for Delaware Water Gap NRA has been developed by Gary Machlis, of the Visitor Services Project. Such a plan represents an organized, written strategy for acquiring social science infor-

Shenandoah National Park Science Advisory Board

The need to expand and strengthen the NPS science program has been recognized for years. This need was highlighted in the 1988 National Park System review conducted by the National Parks and Conservation Association (NPCA). Volume 11 titled, *Research in the Parks*, contained 14 major recommendations, one of which was that Congress should establish a Science Advisory Board (SAB) to provide an expert assessment of NPS natural, cultural, and social science needs and programs.

This need also has been recognized at the field level. Glacier NP has had a review board in operation for several years with very good results. Shenandoah NP established its 7-member Science Advisory Board (SAB) in May 1990. The first board meeting was held in conjunction with the Park's 12th Biennial Research and Resource Management Symposium held in May. The membership is made up of subject matter experts in a wide range of areas including the social sciences. They elected their own chairman, Dr. Robert Adams, head of the Department of Forestry and Wildlife Sciences, Virginia Polytechnic Institute and State University. Initially four of the members will serve two year terms and the remaining three members will serve for three years, thus maintaining program continuity during the first few years. All second terms will be for three years.

The goal of the SAB is to assist the Park Superintendent in the effective protection and management of the natural and cultural resources of the park. As stated in the SAB by-laws, the primary focus will be on providing an annual assessment of the effectiveness of the park's research program and how scientific information is used to make important decisions. Although the Board will not be asked to conduct peer reviews, an examination of the peer review process would be appropriate. The Board may also be asked for input or evaluations on specific management problems or decisions. In response to the SAB's annual report on their findings, the Superintendent agrees to reply in writing to specific recommendations within 60 days. This process will assure timely feedback to the SAB on how their efforts are affecting and contributing to the decision making process.

David A. Haskell
Shenandoah NP

mation useful to park management. The plan reviews existing social science research relevant to the park, identifies research needs, and outlines a 4-year action plan for implementing social science at the park. The plan is the first of its kind and is intended to represent a model for similar plans in other parks. Interested persons may contact Gary Machlis, U/ID, Dept. of Forest Resources, Moscow, ID 83843; (208) 885-7129.

From David Haskell, Shenandoah NP's Chief of Natural Resources and Science, comes news of the park's 12th Biennial Research and Resource Management Symposium May 10-11. The 12 papers given ranged from "The Response of Black Bears to Gypsy Moth Defoliation" to "Watershed Acidification and Spatial Variability of Mountain Headwater Streams of Shenandoah NP."

Second day discussion groups focused on the effects of acid deposition and ozone on park resources, and the Shenandoah Related Lands Initiative, identifying information and research needs.

The first meeting of the park's new Science Review Board (see box) was held. This 7-member board was established to provide oversight and assistance to the park's research program and to review annually the application of science to the management decision-making and problem-solving process.

During the May symposium at Shenandoah NP, James Galloway was awarded the park's Excellence in Service Award for his outstanding contribution to the protection and management of the park's natural resources. For the past 10 years, Dr. Galloway has been the principal investigator for the Shenandoah Watershed study, a long-term research and monitoring program conducted under cooperative agreement with the park. The program is focused on gaining better understanding of watershed response to acid deposition and is the longest running watershed study within an NPS unit. Dr. Galloway also is a member of the park's newly-formed Science Advisory Board.

Five members of Shenandoah NP's Division of Natural Resources and Science were presented with special achievement awards for outstanding accomplishments in 1989: Supervisory Natural Resource Specialist Rick Potts, Administrative Assistant Debra Sanders, Geographic Information System Specialist Alison Teetor, Air Quality Specialist Jim Watkins, and Air Quality Technician Rolf Gubler.

Rocky Mountain

The Artificial Intelligence group at Colorado State University is investigating the possibility of forecasting back-country and wilderness recreation use using innovative computer techniques. The immediate project is a comparison of neural networks/back-propagation for trend identification with exponential smoothing and box-jenkins. The project leader is seeking test data sets and wants to contact others interested in AI and forecasting. Additional areas include embedding neural networks in GIS systems. Contact Douglas Pattie, Dept. of Recreation Resources, Colorado State U, Fort Collins, CO 80523; (303) 491-6477 or 6591; FAX (303) 491-2255.

Further submissions from Rocky Mountain Region will appear in the Winter issue.

Water Resources Division

Terence P. Boyle, Research Ecologist with the Water Resources Division, spent nearly a month in Argentina and Uruguay last winter, attending the Primer Congreso Latino Americano de Ecología meeting in Montevideo, where he led a workshop on the use of resource inventories in ecosystem risk assessment and environmental protection; conferring with various scientists, and visiting institutions in Argentina the week before and after the Congress. Boyle described the conference as similar in scope to an Ecological Society of America meeting, but expressed disappointment that regional problems were not presented within a framework that recognized the international nature of such problems.

Boyle met with Marta Balderiote, head of the Argentine MAB committee, and her staff for discussion of activities at Argentina's four MAB sites. One of the four areas – Parque Dostero del Sur – consists of a narrow belt (30,000 ha) of *Spartina* marsh and dune communities of *Celtis* abutting the coast. This area, which contains several small towns, has been discussed as a potential sister area with Cumberland Island NS for comparative studies with U.S. NPS and MAB.

North Atlantic

The recently established NPS Coastal Research Center at the University of Rhode Island, a CPSU, now is fully operational. Charles Roman, Unit Leader and wetlands ecologist, along with James Allen (coastal geomorphologist), P.A. Buckley (seabird and colonial waterbird ecologist), Howard Ginsberg (entomologist/invertebrate ecologist), and John Tanacredi (environmental toxicologist/ecologist), form a diversified NPS staff capable of addressing issues relevant to coastal parks. Tanacredi, a Gateway NRA based scientist, will commit 30 percent time to the coastal unit. URI researchers, mostly serving in collaboration with the NPS scientists as principal investigators, are becoming actively integrated into numerous research projects at North and Mid-Atlantic parks. Future collaboration with units of the Southeast Region is expected, especially with respect to accelerated sea level rise and related effects on coastal resources and processes.

A two-day conference on Science and Resource Management in the North Atlantic Region is being planned for late Winter-early Spring 1991, in Newport RI. A similar conference in 1987 (Amherst, MA) was a great success and we are looking forward to providing once again a forum for NPS and university researchers, resource management specialists, and superintendents to interact. Please contact Regional Chief Scientist Mary Foley or URI/CPSU Leader Charles Roman with recommendations for session topics.

Dr. Howard Ginsberg recently joined the Office of Scientific Studies. He is duty-stationed at the URI/CPSU. For the past five years, Ginsberg has been an assistant research professor at Rutgers University with a research focus on tick ecology and Lyme Disease. Working in conjunction with the Rutgers Cooperative Research Unit, his research focused on Fire Island National Seashore and other parks of the North and Mid-Atlantic Region. In his new position, Howie will continue to pursue the ecology of insect-borne diseases as well as focusing on biodiversity issues.

Northern Spotted Owl Is Threatened

In June, 1990, the USFWS designated the northern spotted owl a threatened species throughout its range under provisions of the Endangered Species Act. The scientific basis for this determination is presented in a concise report prepared by a 5-person "listing team" of USFWS biologists (Anderson et al, 1990).

Briefly, the USFWS team examined the habitat relationships, population dynamics, rates of habitat fragmentation, and the existing regulatory mechanisms to protect the bird before recommending threatened status. In one particularly interesting comparison of owl occurrence and reproductive performance they conclude that the "... spotted owl habitat in protected areas [e.g. wilderness areas and parks] is too fragmented, isolated, and poor in quality to support a viable population of northern spotted owls." These independent analyses support and expand interpretations on the status of the owl made earlier by the Interagency Scientific Committee (Thomas et al, 1990). They also underscore NPS concerns that persistence of the birds in national parks, particularly the mountain parks of Washington and Oregon, may depend upon retaining populations outside.

Doug Houston, Research Biologist
Pacific Northwest Region

References

- Anderson, D.R. et al. 1990. 1990 Status review, Northern Spotted Owl (*Strix occidentalis caurina*). U.S. Fish and Wildlife Service Report. 95 pp.
Thomas, J.W. et al. 1990. A conservation strategy for the northern spotted owl. Report of the Interagency Scientific Committee. May, 1990. 427 pp.

Pacific Northwest

Dr. R. Gerald Wright, Research Biologist at the NPS CPSU at U/ID, has been selected from this region to be on the NPS Liaison Committee, established to facilitate communications with the National Academy of Sciences Committee reviewing and evaluating scientific research in the NPS.

After an early spring "stir" over sighting of an adult wolf in the drawdown of Ross Lake in the North Cascades National Park complex, automatic cameras were set up at two locations within the Hozomeen area in the hope of recording a wolf visit to the bait (which was roadkill uгуlate parts). By mid-August the cameras were removed. The camera crew had developed great photographs of black bears, ravens, jays, mountain lions, and coyotes – but no wolves, and no grizzly bears.

Meanwhile, several of the park staff (Ross Lake and backcountry people) were trained in how to howl like a wolf and how to recognize a wolf response. Howling transects were being conducted in the area throughout the summer.

In response to a lawsuit filed against the NPS by the Sierra Club Legal Defense Fund, representing the North Cascades Conservation Council (also known as N3C), the NPS is preparing an Environmental Impact

Statement (EIS) dealing with the concerns expressed by N3C. The EIS is examining firewood management, land protection, transportation, wilderness, sand, rock and gravel extraction sites and uses, and management alternatives for the Stehekin River.

Will the elk in Olympic NP persist over time? That's the question constituting the title of an article by Douglas B. Houston, Ed G. Schreiner, and Bruce B. Moorhead of Olympic NP and K.A. Krueger of Bellevue, WA, in the *Natural Areas Journal* Vol. 10(1), 1990, pp 6-11. Recent studies of elk (*Cervus elaphus*) distribution, density, life habits, and vegetation relationships suggest that migratory subpopulations along the east side may be vulnerable because of their low numbers and increased urbanization of winter ranges outside the park. In contrast, subpopulations along west side drainages that winter in rain forests are thought to be comparatively secure.

A draft final report on the Crater Lake hydrothermal research begun in 1986 at the behest of Congress (see *Park Science* Spring 1989) is due September 1990 from Drs. Jack Dymond and Robert Collier – two oceanographers from Oregon State University, who developed a research plan to examine the lake floor for hydrothermal activity. The report, describing three years of dramatic and intensive research, will go through scientific peer review, after which the Secretary of the Interior will use to prepare his report to Congress on the presence or absence of significant thermal features in Crater Lake NP.

Alaska Region

Recent personnel changes in the Region's Natural Resources staff gives us the following field area lineup: Bering Land Bridge, Rich Harris; Glacier Bay, Mark Schroeder; Katmai, Janis Meldrum and Ron Squibb; Kenai Fjords, Bud Rice; Gates of the Arctic, Judy Alderson; Lake Clark, Joe Fowler and Trainee Paul McLaughlin; Northwest Alaska Areas, Lee Anne Ayres and Jim Peterson; Wrangell-St. Elias, Russ Galipeau and Bill Rowdy; Yukon-Charley Rivers, Steve Ulvi and Penny Knuckles; Regional Office, Trainee Sue Mills.

Two radio-collared wolves (plus possibly more that were not collared) were killed in a snow avalanche in Denali. The collars permitted detection of this incident of nature in the raw, and recovery of the carcasses. The wolves were collared as part of an ongoing study under P.I. Dave Mech, FWS.

Episodic eruptions of National Natural Landmark Mt. Redoubt have created a nuisance in Southcentral Alaska since early winter, with portions of the landmark in the form of ash disrupting airline service and generally dirtying the landscape. This spring when the ice melted out of 45-mile-long Lake Clark, in Lake Clark NP and Preserve, the water – instead of its usual springtime deep turquoise color – was clouded with ash, making it look more like it does at the end of a summer, as a result of glacial silt. The redoubtable Dr. Bob Stottlemeyer, who has studied the lake, was summoned for a prognosis.

Continued on page 12

Alaska Region (Continued)

Papers presented at the 70th annual meeting of the American Society of Mammalogists, Frostburg State Univ., June 9-13:

Dale, B.W., L.G. Adams, and R.T. Bowyer (UAF), Influence of late winter caribou availability on wolf predation (NRPP study in Gates of the Arctic); and Rachlow, J.L. (UAF), and R.T. Bowyer (UAF), Use and selection of lambing habitat by Dall's sheep (partial ARO funding, Denali).

* * *

This summer Alaska experienced one of the most active wildfire seasons since records have been kept. An article on the 1990 fire season in Alaska and a discussion of the effectiveness and efficiency of the interagency fire management plans is promised for the winter issue.

National Capital

Seth Riley, wildlife biologist at the Center for Urban Ecology (CUE), gave a paper on "Population Estimation for Raccoons (*Procyon lotor*) in an Urban National Park: 1982-1989" at the 70th annual meeting of the American Society of Mammalogists in Frostburg, MD. John Haddian of CUE and David Manski of Cape Cod NS were co-authors.

* * *

John Short, soil scientist at CUE, is the PI for two research projects studying the urban soils of the Washington Monument grounds. The first project is designed to physically and chemically characterize these soils and to evaluate taxonomic criteria proposed for use with them. Preliminary results indicate that, as expected, the soils are highly compacted, have a variable organic matter content, a relatively high pH, and contain many contrasting layers of soil materials in a single profile.

Short has initiated a project to characterize the soil atmosphere of the Monument grounds soils. The compacted nature of the soil adversely alters the soil atmosphere and therefore quantitative data about these changes are needed. The methodology for obtaining samples has been selected and field sampling will begin soon.

* * *

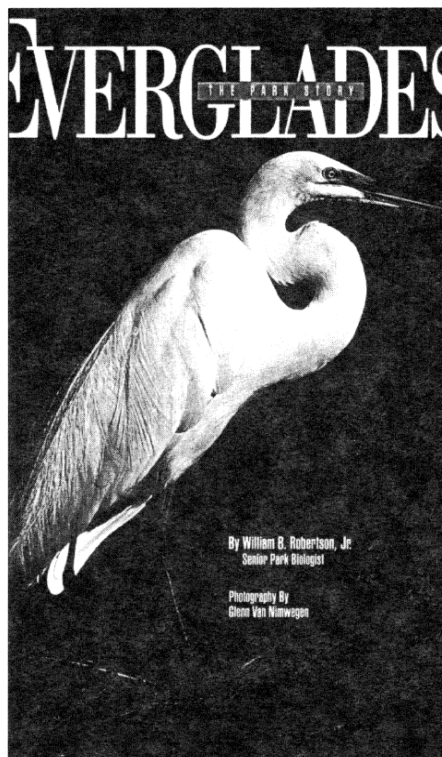
The report "Preliminary Assessment of the Susceptibilities of Non-Target Lepidopteran Species to *Bacillus thuringiensis* (B.t.) and Dimilin Used for Gypsy Moth Suppression" has been completed. Copies of the report, by Adrienne Venables of the U/MD Dept. of Entomology, can be requested from Dr. James L. Sherald, CUE, National Capital Region, NPS, 1100 Ohio Dr., S.W., Washington DC 20242.

* * *

Limited investigations concerning ecology of hydrilla in the freshwater Potomac estuary have been reinstituted due to a dramatic population collapse in the study area in 1989. The collapse, which was unexpectedly strong and almost total in several reaches, has spurred investigation along several lines. Were such factors as turbidity and cloud cover alone enough to cause complete loss of plants? To what extent will hydrilla or other local submersed aquatic vegetation repopulate the supposedly vacant niche under the environmental conditions extant in 1990? Will heretofore weak

Everglades Classic Rewritten and Reissued

William B. Robertson, Jr., Senior Park Biologist at Everglades NP, has lovingly reworked the classic story of the Everglades and it has been beautifully published by the Florida National Parks and Monuments Association, Inc. Writes "Dr. Bill" in his Preface:



"As well as I can remember, I wrote the original draft of *Everglades - The Park Story* in two or three hectic weeks during the summer of 1958. Dan Beard said he wanted a park book and one didn't like to keep him waiting. After the customary editorial agonies, the book appeared a year or so later, suitably clothed in Dade Thornton's fine photographs. At that time it cost a mere buck and it stayed in print for nearly 20 years, while south Florida changed around it.

back from 1988, those days seem unimaginably remote. The park was still in its age of innocence: small staff, not much money, 20-hp outboards, few visitors. Specialization was a luxury we couldn't afford and serendipity lived."

The Preface goes on to describe the "archaic, unprogrammed zest" of the place then - days when "the glades flooded or they didn't flood, an act of God and that was that." And it winds up this way:

"Let us hope that the park continues relatively unscathed through the next several decades of testing confrontations and final adjustments. Then, when someone else sits down to write a better *Park Story* after a while, he can speak of wood storks and panthers and everything else that makes southern Florida wildlands such a glory to behold."

One doubts that a "better story" will ever be written about the Everglades. Robertson's insights have provided the framework for 30 years of park research and resource management, and he is one of the few scientists whose writing skills match his scientific expertise.

This version of the book also is "suitably clothed" - with photographs by Glenn Van Nimwegen, whose work has appeared in *Smithsonian*, *Audubon*, *National Wildlife*, and other publications.

For information on the book, contact Florida National Parks and Monuments Assn., Inc., PO Box 279, Homestead, FL 33030.

pathogens and insects play a more dominant role in controlling hydrilla where the hydrilla population may be stressed?

Western Region

The Region is in the process of establishing a CPSU technical report series, to consist of prepublication material from research conducted in National Parks located within the Colorado Plateau. Anyone interested in being on the mailing list for these reports should send name, address, and affiliation (where the reports should be sent) to Charles van Riper III, Unit Leader; NPS/CPSU, Center for Colorado Plateau Studies, Box 5613, Northern Arizona University, Flagstaff, AZ 86011.

* * *

An 80-page Technical Report (#40), by John A. Sacklin (in partial fulfillment of his master's degree in business administration at Humboldt State University in Arcata, CA), evaluates the operations evaluation process within the NPS and finds the process barely worth the effort as it now functions. One of the strongest recommendations was for more and better follow-up, providing incentive and merit pay systems to reward excellence based on the Operations Evaluation process, and revisiting troublesome areas at a later date to see what progress has been made. Also recommended was that Operations Evaluation results be analyzed to help justify Servicewide funding increases.

letters

To the Editor:

If *Park Science* had a society column, this is the type of note it would carry:

"In 1989 a female peregrine hacked at Isle Royale in 1988 found a mate from Chicago and nested successfully on a building in downtown Milwaukee, Wisconsin." . . . and they lived happily ever after!

The quoted material is from *Ecological Studies of Wolves on Isle Royale, Annual Report, 1989-90*, Rolf O. Peterson, School of Forestry and Wood Products, Michigan Technological University, Houghton, MI.

Also, you may want to do an article soon on the razorback sucker, an ugly fish that is just being proposed as endangered and which we have in Glen Canyon and Lake Mead. It's the fourth fish to be listed from the Colorado River system and symbolic of the entire issue of development and water use all over the west. Am. Fisheries Soc. identified southwestern fish as the most endangered in the U.S. last year and said the trend is down. Most people don't think of fish when they think of endangered species.

Margaret Osborne

Endangered Species Program Analyst
NPS Washington Office

Editor's Note: Margaret has kept us on the ball about desert tortoises, Florida panthers, red wolves, and other rare and endangered sharers of the planet. We acknowledge her participation with enthusiastic thanks.

GLOBAL CHANGE

October 1990

This special section discusses potential Impact and Implications for the NPS

The greenhouse effect is real – a natural function of various constituent gases in the atmosphere that limit the radiation of heat energy from the Earth to outer space. Without the greenhouse effect, the Earth's surface would be about 60 degrees C cooler.

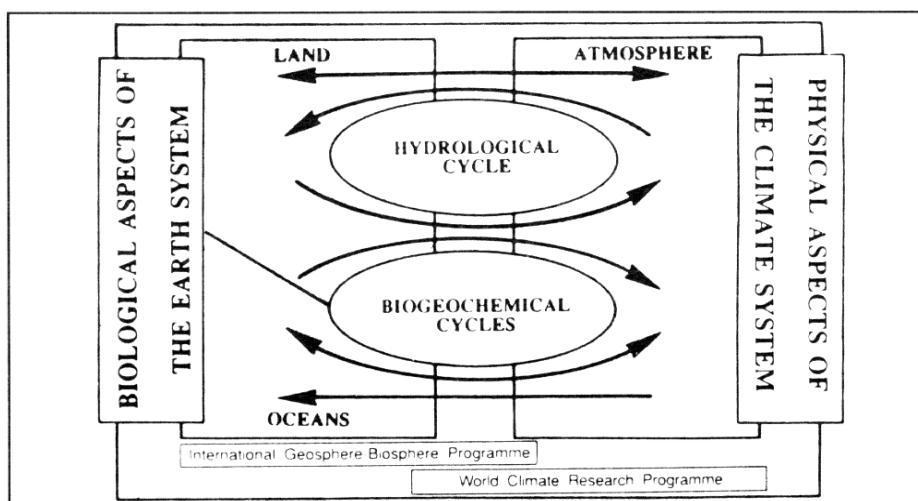
The overarching indicator of global change is a persistent trend toward worldwide climate change that goes beyond so-called normal variation and that seems likely to lead to intensified and unpredictable events in nature.

The concern of the world's governments and the scientific community is manifest in unprecedented basic research initiatives to detect, understand, and predict global change. These initiatives involve an expanding network for cooperation in setting research priorities and objectives and gathering, sharing, storing, retrieving, and utilizing relevant data. U.S. participation in these initiatives is backed by a substantial budget for global change research (see Table 1).

The greenhouse effect has become an issue of global concern because

- the cumulative effects of human (anthropogenic) influences in increasing the concentration of greenhouse gases appears to be either causing climate change or accelerating natural cycles and trends, and
- these changes seem to be occurring at a rate 10 to 60 times faster than any known previous climate change.

The evidence so far shows the Earth to have warmed about 0.5 degree C (about 1 degree F) in the past 100 years. Although a number of periods of both



Linkages among biological, chemical and physical processes critical to our understanding of global change on a decade-to-century time scale. Arrows refer to the seven first research priority questions as described in *The IGBP Global Change Report*, #12, 1990.

cooling and warming took place during that time, the six warmest years on record all have occurred within the past decade. The Earth now is warmer than at any time in recorded history.

If global warming is in fact occurring, the actual mean temperature increase involved will not be the primary focus of concern for natural resource managers.

Rather, it will be the magnitude, frequency, geographic extent, and duration of the climatic "events" – the episodic events of wildfire, hurricanes, drought, etc. – that could accompany even a modest overall warming. These are the kinds of events that are known to cause significant changes in ecosystems. These changes, if

Continued on page 2

Table 1: FY 1990-1991 U.S. Global Change Research Program Focused Budget (Dollars in Millions)

Focused Program	Total Budget		Climate & Hydro-logic Systems		Biogeochemical Dynamics		Ecological Systems and Dynamics		Earth System History		Human Interactions		Solid Earth Processes		Solar Influences	
	FY90	FY91	FY90	FY91	FY90	FY91	FY90	FY91	FY90	FY91	FY90	FY91	FY90	FY91	FY90	FY91
Agency Totals	659.3	1034.1	291.7	461.5	198.7	265.8	90.2	178.6	7.7	19.1	4.8	15.0	57.4	80.9	8.8	13.2
DOC/NOAA	18.0	87.0	14.2	67.6	3.3	13.5	0.0	4.9	0.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0
DOE	50.0	66.0	32.0	44.0	7.0	9.0	9.0	10.0	0.0	0.0	2.0	3.0	0.0	0.0	0.0	0.0
DOI	13.3	43.7	4.9	12.2	0.8	2.0	0.9	10.3	2.4	8.0	0.9	5.3	3.4	5.9	0.0	0.0
EPA	13.2	26.0	1.0	3.3	2.5	3.1	9.7	19.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NASA	488.6	661.0	221.4	302.5	162.2	198.3	51.0	90.0	0.0	0.0	0.0	0.0	47.7	63.0	6.3	7.2
NSF	55.0	103.0	16.8	29.8	20.2	32.2	3.5	8.5	4.5	9.0	1.2	5.5	6.3	12.0	2.5	6.0
USDA	21.2	47.4	1.4	2.1	2.7	7.7	16.1	35.3	0.3	1.1	0.7	1.2	0.0	0.0	0.0	0.0
Scientific Objective																
Observations	137.2	255.0	89.1	148.9	17.2	38.9	14.1	39.6	0.0	0.2	0.0	2.2	13.1	20.8	3.7	4.4
Data Management	65.2	129.4	32.9	64.0	21.2	34.7	5.5	17.7	0.5	2.2	0.4	1.0	3.8	8.8	0.9	1.0
Understanding	409.7	560.0	143.1	200.3	148.1	176.2	65.5	103.2	6.1	13.1	2.9	10.6	40.5	50.1	3.5	6.5
Prediction	47.2	89.7	26.6	48.3	12.2	16.0	5.1	18.1	1.1	3.6	1.5	1.2	0.0	1.2	0.7	1.3

The Assistant Secretary of the Interior for Fish, Wildlife, and Parks is the Departmental overseer of the NPS Global Change Program, which is headed by NPS Assistant Director for Natural Resources Eugene Hester. The Global Change Program organizational chart is available from the Regional Chief Scientists and from the new Washington Office Global Change Program Coordinator, Pete Comanor. (See bio, page 8.) (Table: From USGC Research Program Report for FY 1991, pp. 18-19.)

and when they occur, will define the new limits within which resource managers will have to operate.

Circumstantial Evidence

The evidence on the climatological effects of anthropogenic increases in carbon dioxide, methane, nitrous oxide, chlorofluorocarbons (CFCs), and several minor greenhouse gases is circumstantial. But most global circulation models (GCMs) indicate that, with an equivalent doubling of CO₂ levels by mid-21st Century, the average global temperature can be expected to increase by 3 to 5 degrees C (5 to 9 degrees F) (*Intergovernmental Panel on Climate Change*, May 2, 1990). The probability of an increase of this magnitude is subject to considerable debate, although even conservative authorities concede it at least a 50-50 chance – a probability level that, from a policy perspective, warrants significant concern.

In addition to the direct effects of climate change, an accelerated rise in sea level is expected as a result of warming-induced expansion of the oceans and potential melting of polar ice. According to the IPCC Report (referenced above):

"By 2030, even if greenhouse forcing increased no further, there would still be a commitment to a continuing sea level rise for many decades and even centuries, due to delays in climate, ocean, and ice mass responses. Sea level would go on rising from 2030 to 2100 by as much again as from 1990 to 2030, due to the effects of pre-2030 greenhouse gas increases alone." (See Figures, p. 7)

Changes much larger than those suggested by the GCMs have occurred many times in the Earth's geologic history and no doubt are likely to occur naturally sometime in the planetary future. However, never in human recorded history have such global climatic and related changes occurred at the rate projected and with the degree of human involvement that is now being investigated.

Uncertainties Abound

Many uncertainties cloud our predictions, particularly with regard to the timing, magnitude, and regional patterns of climate change. These uncertainties stem particularly from our incomplete understanding of:

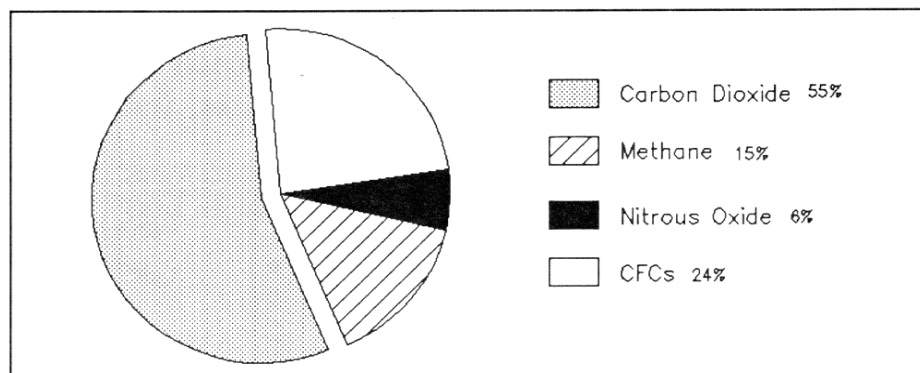
- the sources and sinks of greenhouse gases, which affect predictions of future concentrations;
- the role of clouds, which strongly influence the magnitude of climate changes;
- the role of the oceans, which influence the timing and patterns of climate change;
- the role of polar ice sheets, which affect predictions of sea-level rise.

These dynamic earth system processes are partially understood. Proposed research will reduce the uncertainties, but the complexity of the overall system means that surprises cannot be ruled out, particularly with regard to natural systems.

Potential Management Problems

The potential ecological effects of a 3 to 5 degree C annual global warming projected to occur by mid-21st Century were discussed in the Conference on Consequences of the Greenhouse Effect for Biological Diversity, organized by the World Wildlife Fund and cosponsored by the NPS and other agencies in October, 1988. The Conference provided a valuable summary of the kinds of effects likely to be of special interest to natural resource managers.

Some notable examples include changes in timing and rates of snowmelt, and associated effects such as acid pulse; and changes in the frequency of hurricanes, with reduced productivity of mangroves and



The contribution from each of the man-made greenhouse gases to the change in radiative forcing from 1980 to 1990. The contribution from tropospheric ozone may also be significant but it is difficult to quantify.

GLOBAL WARMING POTENTIALS OF GREENHOUSE GASES RELATIVE TO CO₂

	Time Horizon		
	20 yr.	100 yr.	500 yr.
Carbon dioxide	1	1	1
Methane	63	21	9
Nitrous oxide	270	290	190
Chloro-fluorocarbons	4100-7100	1500-7300	510-4500

(Figures are best estimates calculated on basis of present day atmosphere.)

other hurricane-influenced ecosystems. For some plant species, the direct effects of rising levels of CO₂ in increasing the rate of photosynthesis (the so-called "CO₂ fertilization" effect) and reducing evapotranspiration could be significant, with potential ramifications at the ecosystem, biome, and biosphere levels. Robin Graham, Monica Turner, and Virginia Dale have provided an excellent overview of the state of knowledge of the effects of CO₂ and climate change on forests in the September 1990 issue of *BioScience*.

There may be major shifts in distribution of common forest trees. Preliminary research indicates that the range of such important deciduous forest species as sugar maple, beech, yellow birch, and eastern hemlock might have to shift 500 km northward under global warming, with accompanying extinction throughout much of their existing ranges. Failure of reproduction in areas outside a species' climatological limits is likely to be an early sign of change.

Targets of Heat Stress

Animals that require multiple habitats for completing their life cycles, such as amphibians and migratory birds, could experience significant stress. Heat stress could affect the survival of embryos of ground-nesting birds, animals such as pocket mice that burrow underground to reduce heat loads, and cold-blooded species, such as many desert lizards, with distributions determined by temperature. It also could encourage increased aggression, competition, and other behavioral impacts on many animals. Natural shifts in ranges may be especially difficult for animals with low fecundity or low natural rates of dispersal. Animals known to be subject to temperature-induced switching of sex ratios, such as some turtles and geckos, could be at a

particular disadvantage.

Species relationships, such as plant-herbivore interactions, and the distribution and abundance of parasites could change. The possibility of rapid proliferation of species, including disease organisms, able to invade habitats affected by climatic stress and related disturbances, such as wildfire, is a major concern.

A Letter To The Parks

The list of ecological resources and regions likely to be especially vulnerable to the effects of climate change reads like a letter to the National Park System: Arctic tundra, and boreal forests; alpine, subalpine and relict communities; western forests; coastal lagoons, marshes, and coastal barriers; coral reefs; and many populations of endangered, threatened, rare, and endemic species. GCMs are in general agreement that the magnitude of global warming is likely to be greater at high latitudes and in mid-continental areas. In North America, these are areas where the National Park System is particularly well represented.

A large inventory of the nation's cultural resources also is potentially at risk from the effects of global change. Sea level rise could threaten lighthouses, coastal fortifications, archaeological sites, and other cultural resources in coastal areas. Rising groundwater levels could result in structural damage to foundations of historic structures in affected areas. Increased precipitation in arid areas would adversely affect adobe and other climate-sensitive materials.

Overall, the ecological and cultural heritage included in the National Park System, by any measure, ranks high on the list of resources at risk from the effects of global change.

Continued on page 7

NPS Biogeographical Research Areas



This map illustrates the location of the 11 biogeographic areas selected for inclusion in the FY 1991 Global Change Research Program. They are numbered as follows: 1, Colorado Rockies; 2, Florida Keys; 3, Glacier National Park Area; 4, Great Basin; 5, Northwest Alaska; 6, Olympic Peninsula; 7, Ozark Highlands; 8, Sonoran Desert; 9, Southern Blue Ridge; 10, Southern and Central Sierra Nevada; 11, Western Lake Forest. Number 12 indicates the location of the coastal barrier thematic program.

Because we are a management agency and must manage in a biogeographic context, the NPS has adopted a biogeographic approach to its global change research tasks. Each of the biogeographic areas selected to prepare Global Change Operations and Conceptual Research Plans will build a program that addresses the basic scientific questions posed by the U.S. Global Change Research Program while also providing the basic understanding needed to develop adaptive management policies and programs.

Each of these programs will encourage interdisciplinary and interagency cooperation within the biogeographic area, as well as cooperation with research programs in other biogeographical areas and internationally on particular research themes. The thematic initiatives, which will be identified as the long-term program matures, will provide the basis for NPS scientific leadership.

Please turn to page 4.

The following section provides thumbnail sketches of global change research concepts being considered for inclusion in the NPS Global Change Research Program. A twelfth description is included for the coastal barriers thematic initiative.

Colorado Rockies. (core park: Rocky Mountain NP) The proposed program will follow an hierarchical approach, ranging from the study of global and regional effects of global change to those on the landscape and local levels. This global change research will utilize regional climate models to determine possible scenarios; these scenarios will then be used to predict ecological effects. An analysis of precipitation amounts, seasonalities, and intensities will be undertaken. A paleoecology component includes a study of historical records of debris flows. Additional studies will cover the impacts on lakes and streams, and vegetation changes due to changing characteristics and loss of soil.

Florida Keys. (core parks: Biscayne NP, Everglades NP, Fort Jefferson NM) The proposed program centers on the 200-mile-long Florida Keys coral reef track from Biscayne NP to Fort Jefferson NM. This program includes a study of the sensitivity of the corals themselves to factors associated with global change, such as temperature change and sea level rise, and will investigate the possibility of a drowning of the coral reef system due to sea level rise and potential adverse effects of increased water temperature. This research program will correlate the reconstruction of paleoclimates based upon records contained in coral, such as changes in salinity and deep water upwelling, with contemporary monitoring of regional sea water temperature, currents, and salinity. Studies of the effects of storm intensity on seagrass and coral reef productivity also have been proposed.

Glacier. (core park: Glacier NP) The proposed program has four primary components. Investigators plan to conduct a landscape analysis, with an emphasis on ecotones and shifting landscape patterns, and will study the diversity of topography and the possibility of rapidly shifting ecological boundaries. The alpine zone will also be studied; researchers anticipate that this

zone may change dramatically, but are not certain yet how dramatic the change will be. A third component is watershed analysis, and a study of the links between weather patterns. A paleoecology component also is planned, including lake sediment analysis, tree ring coring, pollen profile analysis, and glacier coring, with the possibility of as much as a 12,000 year history.

Great Basin. (core park: Great Basin NP) The proposed program is primarily comprised of baseline monitoring studies. It will utilize a system of remote weather stations and an upgraded, Class I air quality monitoring station. Paleoecological studies (particularly dendrochronology) will be used as a tool for understanding the past and as clues to the future. The program will investigate relict species and biogeography, as well as plant community fluctuations, with respect to elevational gradients and Great Basin's location at the convergence of three weather systems. In addition, the Great Basin program will examine the chemical and biological sensitivity of small watersheds.

Northwest Alaska. (core parks: Bering Land Bridge NP, Cape Krusenstern NM, Noatak NP) The proposed program focuses on comparison of the impact of climatic change with other forces (e.g., herbivores, fire) on the sensitive resources of the Arctic regions. The program will include studies on response of the tree line to temperature change. The impact of global change on aquatics also will be investigated. With 27 percent of the world's soil carbon stored in Arctic peat soil and permafrost, the potential for mass release of carbon dioxide and methane into the water is significant. The program will monitor and study changes in this soil and permafrost. In addition, the potential implications of global change for native people will be studied.

Olympic Peninsula. (core park: Olympic NP) The proposed program concentrates primarily on sub-alpine and alpine environments. As the Olympic Peninsula has, within a relatively small area, some of the wettest and driest areas in the United States, changes in precipitation patterns and quantities and their relation to global change could have significant effects. Of particular interest is the physiological response of

trees and other vegetation at high elevations and in old-growth forests to the effects of global change. The program includes research on global change effects on stream hydrology and chemistry. In addition, the program will examine the effects of changing environmental conditions on the physical and ecological processes associated with disturbances such as fire, avalanches, and glaciation.

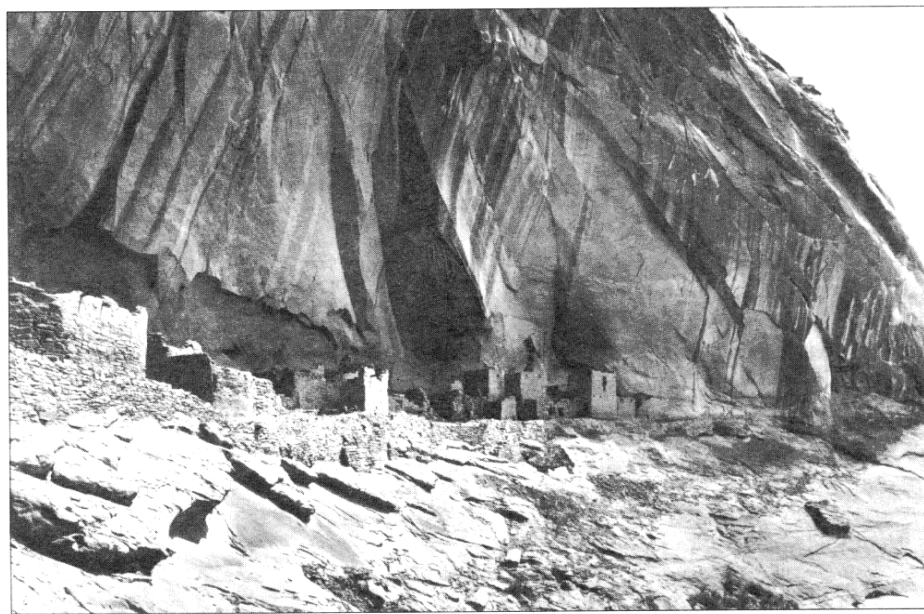
Ozark Highlands. (core parks: Buffalo NSR, Ozark NSR) The proposed program concentrates primarily on aquatic resources. The effects of global change on the spring-fed aquatic systems of Ozark NSR will be compared with the effects on the precipitation-fed systems of Buffalo NSR. The correlation of red cedar chronology and stream flow regimes will be investigated, and the current records will be expanded to develop a model of the predicted effects of global change. The plants and animals of the Ozark springs, and the distribution and abundance of fish, will be studied to determine their sensitivity to global change. Social scientists will study potential effects on recreational uses, and construct correlative models using the "dust bowl" records of the 1930s.

Sonoran Desert. (core park: Organ Pipe Cactus NM) The proposed program studies how climate affects species distribution and structure in the desert environment. The investigators will integrate existing primary data sets into a geographic information system designed for the global change program. Specific activities include monitoring soil moisture and temperature and relating these properties to sensitive animal species such as the desert tortoise, and comparing remote Organ Pipe Cactus NM and urban impacted Saguaro NM for differences in ecosystem response to climatic change effects in an effort to factor out anthropogenic factors. In addition, researchers plan to experiment with environmental manipulation (e.g., "rain-out shelters") for modeling purposes.

Southern and Central Sierra Nevada. (core park: Sequoia-Kings Canyon NP) The proposed program focuses primarily on disturbance regimes in forested ecosystems, changes in the tree line ecotone, and global change effects on species such as the giant Sequoia that might ensue. This program will also study the tree line ecotone. Models will be developed to predict the types of changes that could be expected under varying climatic conditions. Investigators also plan to monitor what is happening today, such as studying reproductive modes and dispersal, so that climate change could be detected as it occurs. In addition, the study will focus on paleohistorical studies to provide data to test models of climate, disturbance, and biotic change.

Southern Blue Ridge. (core park: Great Smoky Mountains NP) The proposed program includes a characterization of selected sensitive ecological communities and species and their microclimates, and will attempt to correlate soil temperature and moisture regimes with the population dynamics of potentially sensitive species in old-growth forested watersheds. Also planned is a model to predict ecosystem destabilization associated with climate change, development of models of community distribution, watershed processes and response, and application of these models in Shenandoah NP and Great Smoky Mountains NP. The investigators plan to cooperate with the Southern Appalachian Man and the Biosphere Cooperative in studying human influences pertaining to global change.

Western Lake Superior. (core parks: Isle Royale NP, Voyageurs NP) The proposed program focuses on the fringe boreal forest of the Western Lake Forest



Paleoarcheology in relation to the Global Change program involves not only the saving and studying of prehistoric ruins but the investigation of how the inhabitants adapted to environmental conditions (and how, in some cases, they seem to have given up in the face of these changed conditions.) This is Inscription House Ruin at Navajo NM in Arizona.

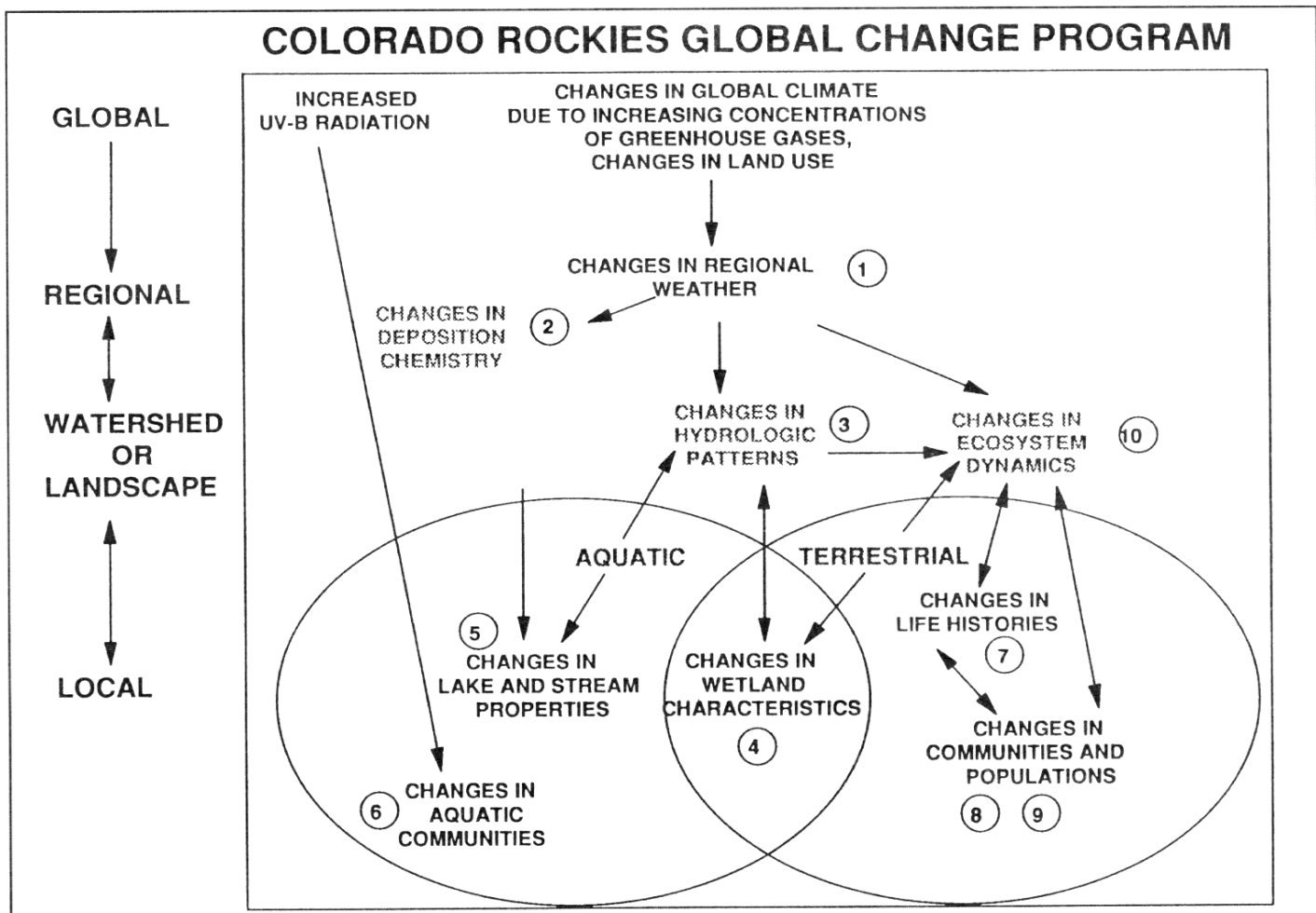


This erosion scene (Cape Hatteras, March, 1973) will be repeated with increasing frequency up and down the nation's coastlines if ocean levels continue to rise and storm events intensify in numbers and strength.

province, with emphasis on change in the nitrogen cycle as an early indicator of climate change. The program will involve contributing sites to the north and west of the core research areas to study the vegetation that may replace the boreal forest. Investigators plan to contribute to a multi-agency university study of the climate of Lake Superior, as well as to collaborate with the Canadian Park Service on boreal forest monitoring studies. The program also plans to institute studies on subsistence and small-scale economic fishing in Lake Superior and Canadian border lakes.

Coastal Barriers. The coastal barrier islands constitute one of the most dynamic natural systems within the National Park System. This thematic research program, which in FY 91 will focus primarily on the Mid-Atlantic NPS units, will be expanded in the out-years to include NPS units on the entire Atlantic and Gulf seaboard. The monitoring and research program will investigate the processes that are directly linked with the physical and biological systems that will respond to a change in climate; sea level, storm frequency and magnitude, air and water temperature, precipitation, and tidal wetland dynamics. Modeling and state-of-the-art GIS will be the foundation of this thematic research program.

An example of the global change research concepts that will be considered for inclusion in the NPS Global Change Research Program is shown below.



Numbers in circles are hypothesis numbers which were discussed in the proposal.



Tree lines march up and down mountain sides to the beat of changing climate regimes.

Global Change Mitigation and Adaptation Research

The CEES is coordinating applied research relating to global change response strategies through the recently established Working Group on Mitigation and Adaptation Research Strategies (MARS). In July, the NPS forwarded concepts for 8 research initiatives to the Department for consideration in planning the inter-agency MARS program:

(1) Adaptive Resource Management in the NPS, a series of workshops and symposia to provide the scientific basis for developing management responses to the effects of global change on NPS natural and cultural resources;

(2) Vulnerability of Natural Ecosystems and Species, to develop information syntheses and methodologies for assessing potential risks to sensitive NPS ecological resources from hypothesized effects of global change.

(3) Biogeographic Cooperatives, to assess existing and potential cooperative mechanisms for addressing global change issues relating in particular biogeographical areas.

(4) Fire As an Adaptive Ecosystem Management Tool, to synthesize information on the relationship between pre- and post-fire climatological conditions and the course of ecological succession in selected biogeographical regions. The program would support adaptive management of vegetation under potential climate change scenarios.

(5) Risk Management on Coastal Systems, a long-term research and modeling program to support adaptive management of NPS coastal barriers under potential changes in sea level, and the magnitude and intensity and tracks of coastal storms.

(6) Adaptive Management of Public Recreation, to assess relationships between past short-term climatic changes and public recreational uses of National Parks to support contingency planning

(7) Adaptation of Small-Scale Societies, to utilize applied anthropology to assess adaptations of native

and other small-scale societies to the potential effects of climate change

(8) Cultural Resource Preservation Research, to develop a strategy for adapting national preservation policy to respond to the environmental effects associated with global change.

The interagency MARS research program is still in the early planning stage. During the next year, emphasis is expected to be on interagency planning in preparation for implementing substantial research beginning in FY 1993.

Meet Pete Comanor

Peter L. Comanor, our new WASO Global Change Program Coordinator, took the reins of the Global Change Program from Bill Gregg on August 27. Pete, who comes from the Bureau of Land Management where he headed their Office of Budget and Management Support, has had a long and varied career, with positions ranging from twelve years at the University of Nevada at Reno to a Smithsonian assignment in Ceylon. Pete received his B.S. in Geology and his M.S. in Botany from Florida, and his Ph.D. in Ecology from Rutgers.

When Pete is not on the job, he enjoys visiting historic and natural areas, listening to music, and chores (*perhaps he could clean John Dennis's office!*) We look forward to having Pete on board. If you'd like to get a hold of him, he can be reached at (202) 343-8126 (FTS 343-8126).

For more information...

For more information, the following publications are recommended. A limited number of copies are available from David Figlio, WASO Wildlife and Vegetation Division, P.O. Box 37127, Washington, DC 20013-7127, (202) 343-8133.

Committee on Earth and Environmental Sciences, ***Our Changing Planet: the FY 1991 Global Change Research Program***, 1990, currently in draft, executive summary available.

Environmental Protection Agency, ***EPA Journal***, Jan./Feb. 1989.

Intergovernmental Panel on Climate Change, May 2, 1990 draft report.

National Science Foundation ***Mosaic***, Fall/Winter 1988.



Recreationists at Assateague Island National Seashore, along with NPS park-users everywhere, may find themselves having to make adjustments in their use patterns in response to management necessitated by climate changes.

The NPS Global Change Research Program

By Bill Gregg, MAB Coordinator for NPS

To understand and address global change effects on ecosystem processes, and related effects on species distributions and life cycles, will require unprecedented cooperation at many levels: interdisciplinary cooperation among global change researchers; among research, educational, and management specialists in participating NPS areas; between these NPS special-

ists and others in the same biogeographic area; and among specialists in different biogeographical areas, including a strong emphasis on building international linkages. To foster the required multi-level cooperation, the NPS adopted the biosphere reserve model for developing its long-term global change research program.

In this model, a biogeographic area, defined on the basis of physical and biological factors and human-environment interactions, provides the geographic framework for developing cooperative programs. Each biogeographic area contains from one to several NPS units as core research areas that will serve as the

Continued on page 8

Continued from page 2

Policy Implications

A reading of the possible consequences of GCC will suggest immediately to resource managers the drastically changing nature of their responsibilities and tasks in the decades ahead. Policy issues, both near- and long-term, raise some interesting questions. The NPS will be concerned in a near-term context with such questions as:

(1) Under conditions of rapid habitat change, should NPS change its management philosophy of minimal intervention?

(2) How should climate uncertainty be incorporated into NPS planning activities?

(3) Should NPS become a more active cooperator in maintaining ecosystems outside park boundaries?

(4) What should be the NPS role in generating scientific information for detecting, understanding, and predicting global change effects?

(5) To what extent should NPS educate the public on the effects of global change?

Longer-term policy issues give rise to a different set of questions:

(1) Should NPS adopt a policy of active vegetation management?

(2) Under what conditions should NPS participate in national or international efforts to rehabilitate degraded ecosystems?

(3) To what extent should NPS encourage *ex situ* maintenance as a means of perpetuating native species?

(4) Under what conditions should the NPS intervene to prevent, mitigate, or lessen the effects of sea level rise?

(5) To what extent should potential sea level rise and climate change be considered in NPS land purchases and boundary modifications?

How Does The U.S. Fit into the World Research Picture?

The U.S. Global Change Research Program is coordinated by the Working Group on Global Change of the interagency Committee on Earth and Environmental Sciences (CEES). The overall goal of the U.S. Program is to "establish the scientific basis for national and international policymaking relating to natural and human-induced changes in the global Earth system."

In the executive summary of *Our Changing Planet: The FY 1991 Research Plan of the U.S. Global Change Research Program*, the CEES underscored the Administration's commitment to improving our understanding of the process and implications of global change:

"Recognizing the profound economic and social implications of responding to global environmental changes, the President has set in motion a comprehensive process designed to continue U.S. leadership on this issue. This includes an accelerated, focused research effort; active participation in international collaborative efforts intended to culminate in a Frame-

work Climate Convention; and a comprehensive review of potential policies and their implications.

"As the research component of this process, the U.S. Global Change Research Program is designed to reduce key scientific uncertainties and to develop more reliable scientific predictions, especially predictions of changes in regional climate, upon which sound policy strategies and responses can be based."

The CEES has structured the U.S. research program around seven interdisciplinary science elements:

- Climate and Hydrologic Systems
- Biogeochemical Dynamics
- Ecological Systems and Dynamics
- Earth System History
- Human Interactions
- Solid Earth Processes
- Solar Influences

The CEES has established technical Task Forces to coordinate interagency programs under each science element, and additional task forces to coordinate activities in the areas of modeling, data management, international coordination, industry and global change science, outreach and communications, and educa-

tion and training. NPS specialists are participating on 11 of the CEES Task Forces.

NPS Research Categories

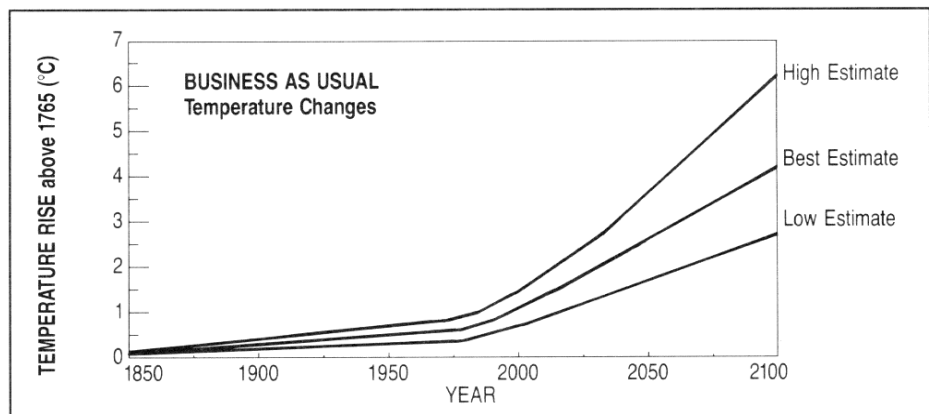
The National Park Service will be conducting global change research within four of the seven interdisciplinary science elements designated by the CEES.

Under Ecological Systems and Dynamics, the NPS will conduct studies to understand the global change interactions at the population, community, watershed and landscape levels.

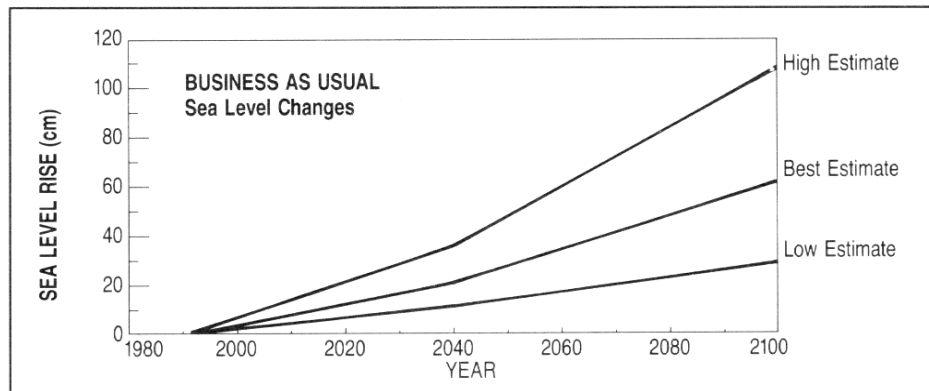
Under Earth System History, NPS will be conducting a variety of paleostudies to provide evidence of past climate change and its effects.

Under Human Interactions, our resource ethnography program will look at the effects of climate change on subsistence and other ecosystem uses of native and other small-scale societies.

And finally, under Solid Earth Processes, we will study the dynamics of coastal systems as affected by sea level rise and changes in the frequency, intensity, and tracks of coastal storms, with emphasis on NPS coastal barriers.



Projected temperature rises (above) and sea level rises (below) shown here represent best estimates according to the Intergovernmental Panel on Climate Change science and policy workgroups (May 2, 1990 draft report).



Research Program

(Continued from page 7)

primary NPS sites for developing coordinated long-term interdisciplinary research programs. The core research areas are either designated units of the UNESCO's International Network of Biosphere Reserves, currently under study, or are considered potentially suitable for designation.

Contributing Areas

In addition to the core research areas, other NPS units in the biogeographic area will serve as contributing areas. The contributing areas will provide study opportunities by virtue of additional data sets through cooperative monitoring and research, and from natural or cultural resources not present in the core research areas. The participating NPS units in each biogeographic area will develop their research programs to address the scientific priorities identified by the CEES in the U.S. Global Change Research Program, while also providing the basic understanding needed to develop adaptive management policies and programs.

Each program will encourage interdisciplinary and interagency cooperation within the biogeographic area, as well as cooperation on particular research themes with other biogeographical areas and internationally. These interregional and international thematic initiatives, which will be identified as the long-term program matures, will provide the basis for NPS scientific leadership in the global change program.

The Review Process

The NPS Global Change Program is based on a process of concept development, program formulation, development of research proposals, and progressive strengthening of operational capabilities in participating field units. The NPS process relies strongly on review of the program and individual research pro-

The Invisible Present

"All of us can sense change – the reddening sky with dawn's new light, the rising strength of lake waves during a thunderstorm, and the changing seasons of plant flowering as temperature and rain affect our landscapes. Some of us see longer-term events and remember that there was less snow last winter or that fishing was better a couple of years ago. But it is the unusual person who senses with any precision changes occurring over decades. At this time scale, we are inclined to think of the world as static, and we typically underestimate the degree of change that does occur. Because we are unable directly to sense slow changes and because we are even more limited in our abilities to interpret their cause- and-effect relations, processes acting over decades are hidden and reside in what I call 'the invisible present.'"

John J. Magnuson, in *BioScience*
July/August 1990, p. 495

posals by NPS and outside specialists using key CEES criteria (relevance to global change program objectives, scientific merit, readiness, linkages, enhancement of existing program research). Higher level reviews of the NPS program by the Department of the Interior and the CEES Working Group on Global Change will also use these criteria and will facilitate

The Invisible Place

"...lack of historical perspective can place short-term studies in the 'invisible present,' where a lack of temporal perspective can produce misleading conclusions. Similarly, the broad significance of research results from a particular site is difficult to interpret if the site's context in space (e.g. location within region-scale variation in disturbance regime and temperature-moisture conditions) is not understood. In this sense, an isolated research site may reside in an 'invisible place' where the significance of results is unclear."

Frederick J. Swanson and Richard E. Sparks
in *BioScience*, July/August 1990, p. 502

coordination among Departmental bureaus and with other agencies. These reviews will maintain a high degree of accountability within the Global Research Program.

The NPS global change program began with the Secretary's establishment of the Departmental Working Group on Global Climate Change (DWGCC) in November 1988, to provide a framework for interagency cooperation in response to CEES priorities. In early 1989, the DWGCC asked each bureau to identify ongoing research programs relevant to the U.S. Global Change Research Program. Bureaus were asked to provide information on "focused" programs targeted and justified to address global change research issues, and "contributing" programs relevant to global change research but justified on other grounds. (Focused programs are funded as components of the interagency U.S. Global Change Research Program; contributing programs are funded through other sources).

Through the Department's initiative, the CEES recognized 17 NPS programs under 5 science elements as contributing programs in the FY 1990 U.S. Global Change Research Plan, published in July 1990. The initiative established the relevance of NPS and other bureau research programs to the global change issues, and provided the opportunity to develop a focused program.

Coordinator Appointed

The NPS Director appointed Eugene Hester, the Associate Director, Natural Resources (ADNR), as the responsible NPS official for developing the NPS program. Dr. Hester designated Dr. William Gregg, the Service's Man and the Biosphere Program Coordinator, to coordinate technical aspects of the NPS program within the Service and with the Department and various CEES scientific Task Forces. Dr. Gregg served in this capacity until the appointment of Peter Comanor as full-time NPS Global Change Coordinator in August (see p. 6).

Through an informal network of WASO and field scientists, the NPS developed proposals for a cooperative integrated program of ecological research in selected biogeographic areas, to serve as the major NPS program emphasis, and a small thematic program to study global change effects on coastal systems. The "integrated studies" proposal called for initiating research in 12 biogeographic areas in FY 1991 and the addition of two biogeographic area programs annually until achievement of the full performance level of 20 biogeographic area programs in FY 1995.

As a result of the coordination between the Department, the CEES, and the OMB, the programs were

included, albeit at a somewhat reduced funding level (\$3 million and 26 FTEs), in the President's FY 1991 budget request to the Congress.

In February 1990, following release of the Administration's budget request, the Director announced the NPS Global Change Research Program: authorized an NPS program committee to plan, coordinate, and oversee the program; and invited parks interested in being considered as core research areas to prepare statements on their research capabilities and interests in global change research.

The Selection Process

NPS units representing 27 biogeographic areas prepared written statements, which were presented orally to the program committee and a group of outside reviewers at a workshop in New Orleans in May. Based on the review group's comments and the program development considerations, the NPS Global Change Program Committee (GCPC) recommended, and the ADNR approved the recommendation, that NPS units in 11 of the biogeographic areas be invited to prepare Global Change Operations and Conceptual Research Plans (GCPs) for participation in the NPS Integrated Studies program, and that planning also be initiated for thematic research initiatives on the effects of global change on coastal barriers and glaciers. Each park that submitted a proposal received feedback from the peer reviewers and the program committee for consideration in preparing their plans or, for the areas not

Contributions of Long-Term Research

"Research with an extended time perspective is crucial if one accepts the premise that long-term phenomena have a central role in ecological science. Such studies are uncommon despite this obvious need and repeated evidence of the misleading nature of short-term research. Factors contributing to the rarity of long-term studies include difficulties in obtaining sustained financial support and in providing continuing leadership."

Jerry Franklin, Caroline Bledsoe, and
James Callahan
in *BioScience*, July/August 1990, p. 509

selected, in deciding whether to revise their concept statements for consideration in the planning and review process for the FY 1992 program cycle.

Plans for the FY 1991 programs are due to the ADNR by October 1, 1990. The plans will be reviewed by outside scientists. In late October, the program committee meets in Seattle to review the plans and the peer review comments, and to recommend personnel and funding allocations for program operation and which research concepts will be developed as full research proposals.

Following the ADNR's approval of the Plans, the core research areas with approved Plans will develop the detailed research proposals and secure outside peer review. Final proposals and accompanying peer review comments must be submitted to the ADNR not later than March 1, 1991. The GCPC will then be asked to review the research proposals and make recommendations to the ADNR by late March. The ADNR will select proposals and complete the allocation of GCP funds by early April 1991.

Archeologist Robert S. Carr, who directs the non-profit Archeological and Historical Conservancy in Miami, FL, told **Science News** (July 7, 1990) that the nearly 40 "earthworks" dotting the landscape of southern Florida's interior may represent North America's earliest known fisheries. John Griffin, retired chief of the NPS Southeast Archaeological Center in Macon, GA, agrees with Carr's interpretation.

The prehistoric network of circular canals and earthen mounds – most discovered by Carr since 1974 – date to as early as 450 B.C. Others originated in the 16th century. The carefully engineered structures indicate that prehistoric hunter-gatherers inhabiting inland regions of southern Florida developed socially stratified societies based on fish harvesting, according to Carr. An agricultural way of life generally is thought to be essential to the rise of social classes, but anthropologists have long noted that Indians along Florida's southern coast developed all the trappings of stratified societies although they hunted and fished instead of planting crops. Carr suggests that their social elite coordinated construction of fish harvesting sites.

An invention about to be tested at sea promises a view of marine life that until now has been hidden beneath the waves, according to newswire reports that moved around July 19, 1990. The system combines newly developed sonar techniques and advanced computer processing to produce three-dimensional images of ocean animals and their activities.

Julius S. Jaffe of the Scripps Institution of Oceanography in La Jolla, CA, inventor of the system, has received a federal grant to test it at sea as part of a large-scale research program called Global Ocean Ecosystem Dynamics. He expects it to provide researchers with a better understanding of marine animals as they react to one another and to environmental changes.

While the Northern spotted owl and the timber industry square off against each other in the Pacific Northwest, a 3-pound rodent known as the Mt. Graham red squirrel is holding up construction on Mt. Graham of seven large telescopes – the dream of astronomers at the University of Arizona in Tucson in collaboration with the Vatican and the Max Planck Institute for Radioastronomy in Bonn, Germany. The clarity of view and isolation from light pollution have prompted astronomers to call Mt. Graham one of the premiere U.S. outposts for observing the heavens.

According to a report in the July 7, 1990 issue of **Science News**, the General Accounting Office (GAO) has found "serious flaws" in a 1988 report by the USFWS, which concluded that Mt. Graham's Emerald Peak is one of two "reasonable and prudent" sites for the telescopes. Although GAO has recommended updating the report, confusion exists as to who can order such an update, under the Endangered Species Act. According to the Act, only the USFS can order such an update. Meanwhile, if delays continue, the University frets that its partners "may pull out."

In 1988, Lois Winter, an NPS interpreter, opted to take a two-year leave of absence to return to graduate school and complete a two-year NPS field research project aimed at bridging the communication gap that

she felt exists among NPS interpreters, resource managers, and researchers.

In April, 1990, she wrote an article on the subject that has been accepted by the NPS's **Interpretation**. She did her work with the help of a Horace Albright research grant and earned a Master's in Wildlife Conservation. Her field research was at Acadia NP.

Her four recommendations, (the guidelines for accomplishing them appear in her **Interpretation** article) are:

1. Designate a "research liaison" in the Interpretive Division of each park, with the formalized duty of forging an effective link between resource managers, researchers, and interpreters.

2. When drafting research proposals, Regional Office Science Divisions should incorporate specific requirements to assure that park interpreters have access to important information from researchers.

3. Because research may have significance in parks other than the one where it was carried out, every Regional Chief of Interpretation should stay in touch with the Region's Chief Scientist. By maintaining a basic awareness of ongoing nationwide NPS research, the Regional Chief of Interpretation can alert each park's "research liaison" of potentially relevant research elsewhere in the NP System. The liaison persons in the parks can pursue worthwhile leads by communicating directly with the appropriate parks.

4. To emphasize its importance, incorporate a section in the Statement for Interpretation detailing interesting research results and describing progress and stumbling blocks in establishing and maintaining the interpreter-researcher connection.

Lois suggests that "only when visitors understand the critical problems that threaten park resources can we expect them to play a role in minimizing those problems. Interpretation is a vital tool in focusing attention on resource issues the confront the parks."

"Black Bear Population Dynamics in Yosemite NP" is the title of Technical Report #39, by Jeffrey A. Keay, in the U/CA/Davis CPSU publication series. The 138-page document consists of 3 indendent papers written for publication in scientific journals, plus a management summary and specific recommendations for Yosemite NP. Sex and age composition and reproductive rates of nuisance black bears (*Ursus americanus*) were examined from 1984 through 1988 in Yosemite NP to assess the effects of an intensive bear management program. A matrix population model was used to evaluate the relative importance of survival and reproductive rates to population growth rate and age structure and the population's ability to withstand the impacts of intensive management.

Obituary

The Region is saddened to report the death of John Dalle-Molle, for many years the Resource Management Specialist at Denali NP and for the last two years of his life at North Cascades NP. Dalle-Molle, who died June 10, 1990, had a wide range of specialties, including bear management, fire management, natural resource management, revegetation/restoration, subsistence uses, and wildlife management. The Region will sorely miss his services.

The **Natural Areas Journal** (Vol. 10 (2), 1990) features an article dealing with "A Synthesis Approach to Research and Management Planning: The Conceptual Development and Implementation," by Allen Steuter and Carolyn E. Grygiel of The Nature Conservancy and Mario Biondini of the North Dakota State University's Animal and Range Sciences Department. Starting from the premise that natural area management at the landscape level implies an understanding of the interactions among ecological forces, and that these interactions can be better understood by an a priori synthesis approach during the development of a management plan, the authors describe a stewardship strategy for mixed prairie preservation. The synthesis approach is used to restore the fire/bison grazing/pocket gopher disturbance interactions to a grassland ecosystem, starting with a conceptual model of a natural area, and proceeding through a hypothesis that the patch dynamics of grassland ecosystems is a hierarchical process organized at different spatial and temporal scales. Findings led to the conclusion that management actions that are independent of landscape context will limit the structure and function of the native communities these actions strive to preserve.

People looking for new job opportunities are reminded that the Student Conservation Association, Inc., of Charlestown, NH 03603, publishes a monthly listing of permanent, seasonal, and internship openings in its **Job Scan** magazine. The SCA phone number in Charlestown is 603/826-4301.

The discovery of a second marbled murrelet nest in a stand of old growth timber in Oregon's Coast Range was made on July 12 in a Douglas fir tree on BLM land, about 20 miles inland from the Pacific coast. The tree was 4 feet in diameter at its base and more than 160 feet tall, according to the BLM, which announced the find. Nelson found the first Oregon nest on May 18. One other murrelet nest – in Washington – brings to 3 the total number of such known nests in the Pacific Northwest.

"Professors' poor prose poses perplexing problem" is the headline on an **L.A. Times-Washington Post News Service** story by Thomas V. DiBacco, a historian at the American University in Washington, DC and author of a high school history textbook. His thesis: "Increasing numbers of professors can't write well."

"Verbosity and pomposity" on the part of professors, DiBacco writes, has lately been exacerbated by "muddled prose." He cites this example, taken from a learned statement on contemporary challenges in higher education:

"But having a focused purpose in mind helps it continually prioritize its goals and objectives within the cross-currents of issues and new circumstances that continually pound on it."

An individual who cannot write clearly (and serve as a model for his students) "is uneducated," says DiBacco, "no matter the credentials." He concludes that professors would do well to heed the words of Francis Bacon, who wrote in 1625: "Reading maketh a full man, conference a ready man, and writing an exact man."

Nature Reserves: Island Theory and Conservation Practice, by Craig L. Shafer, ecologist with the NPS Washington Office, will be published by the Smithsonian Institution Press in October 1990. The island biogeography theory is controversial, and Shafer reviews the literature on this and related subjects, then synthesizes some guidelines for dealing with these theories. His analysis includes ecology, biogeography, evolutionary biology, genetics, and paleobiology, as well as legal, social, and economic issues. The roadmap thus provided through this complicated body of literature is meant for biologists, students, nature reserve managers and planners, and others with conservation responsibilities.

The 208-page book contains 58 black and white illustrations. Clothbound copies will be \$39.95; paper, \$15.95.

**

Madras Plenary Session, the final consensus report of the Keystone International Dialogue Series on Plant Genetic Resources, is now available through the Keystone Center, PO Box 606, Keystone, CO 80435; 303/468-5822. The session was held from Jan. 29 through Feb. 2, 1990, in Madras, India, with 46 individuals from 26 countries taking part. The Dialogue Series involve participants from non-governmental organizations, national governmental organizations, corporations, research institutions, and international and intergovernmental organizations from developed and developing countries.

The recommendations of this Dialogue were formulated with an eye to their usefulness at the June 1992 UN Conference on Environment and Development, to be convened by the UN in Brazil and to focus on issues such as the conservation of biological diversity, the potential of biotechnology, protection of the atmosphere, and protection and management of land resources.

Copies of the **Madras Plenary Session** also are available from **Diversity**, the quarterly news journal for the plant genetic resources community, at 727 8th St. SE, Washington, DC 20003; (202) 543-6843.

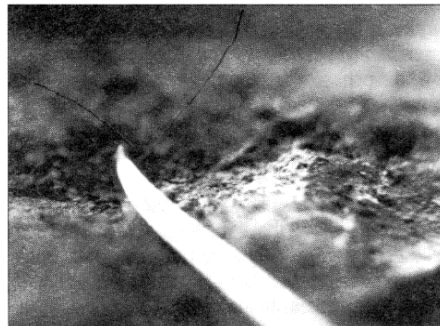
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Islands Under Siege: National Parks and the Politics of External Threats is the title of new 200-page book by John C. Freemuth, assistant professor of political science and public affairs at Boise State University. He has served on advisory panels for the NPS.

If the Park Service can't – or won't – protect our national parks, who will? he asks, and adds, "It's high time we figure that out." Freemuth first examines the "administrative tightrope" the Service has had to walk, "saddled from the beginning with a contradictory mandate – to promote recreational use of parks yet preserve them for future generations." The new crop of threats – environmental degradation from sources outside the parks – Freemuth sees as political problems. He traces the shifts in government action that have accompanied waves of citizen activism and uncovers evidence of ineffective legislation, inept implementation, and the potent political power of pro-development forces. His conclusion analyzes a set of political strategies that have been used to deal with these threats, evaluating each in terms of environmental effectiveness and political feasibility. The clothbound book (ISBN 0-7006-434-0) has nine photographs, five 6x9" maps, and costs \$25.

Oregon State University researchers report finding that many of the shrubs and trees in a massive area of southwest Oregon and northern California actually depend upon water drawn from solid rock by tiny roots deep in stone. Their study, which suggests that millions of acres of vegetation would be near desert without the plants' ability to extract water from more than 10 feet deep into seemingly impenetrable stone, could dramatically alter conventional wisdom about growth patterns and characteristics of many plants in a wide area of the western United States.

Michael Newton, a professor of forest science, describes finding that "after certain shrubs or trees are a few years old, they can and do draw 70 to 80 percent of their water from roots in bedrock during the summer months." Highly competitive shrubs such as manzanita have among the most vigorous capability to send minuscule roots about the thickness of a thread into rock cracks a few thousandths of an inch wide. After a heavy rain, soils can contain from 10 to 35 percent water, Newton said. The typical density of rock is about double that of soil, and rock has fewer pores, but different types of rock can hold from 12 to 22 percent water, and plants may be able to tap into as much as half of that liquid reservoir, the study indicates.



Tiny hairlike roots are shown here growing out of solid rock excavated from about 10 feet below ground surface. They are seen in this close-up photo in comparison with the point of a pair of tweezers.

**

First there was acid rain, which tends to render lake waters sterile. Now comes "the green hand in the sea," which is Victor Smetacek's name for too much fertility. Smetacek is a marine biologist at the Alfred Wegener Institute for Polar and Ocean Research in Bremerhaven, Germany, and he is quoted in the April 1990 issue of **Science**, under a Berlin dateline in the News & Comment section.

The most visible manifestations of that green hand are the red tides, yellow foams, and outbreaks of clinging emerald slime that constitute phytoplankton blooms, says the article. On a small scale, such blooms are part of the natural cycle of the sea, but by supplying extra nourishment, human activities probably have upset this orderly round in many parts of the world. Smetacek has compiled a casebook of "exceptional phytoplankton blooms," "all increasingly toxic" and spelling death for much of the life in the oceans' margins, where 30 percent of the seas' productivity occurs.

At the Ocean Margin Processes in Global Change workshop, held in Berlin March 18-23, 1990, there was strong consensus that whether these conditions reflect global changes or not, there are things going on in ocean margins around the world that will have critical consequences – and soon.

Park Science has been reporting sporadically, as the isolated incidents made the news, on the mysterious disappearance of amphibians. Now Michael Milstein, reporter for the **Billings Gazette**, and a former NPS ranger, does a thorough job for the National Parks and Conservation Association's magazine, **National Parks**, (July-August 1990) of uncovering what is happening to these little noticed denizens of the National Park System. He interviews a cross section of scientists as to possible causes and prognoses. "There are few reassuring signs," he notes. "What is most urgently needed now, biologists say, is research to prove exactly what is killing frogs and their kin. Backcountry rangers working in several NPs, including Canyonlands, Yosemite, and Sequoia, will be on the lookout for healthy amphibian populations this summer."

UCLA Biologist David Bradford mourns the "anecdotal" nature of much of what is now known. Last summer, Bradford found frogs in only one of 46 Sequoia NP ponds where he had studied them in the 1970s.

**

A handsome, hardback, 163-page volume, **Interdisciplinary Approaches to Freshwater Wetlands Research**, edited by Douglas A. Wilcox and published by the Michigan State University Press, East Lansing, is Volume 7 of a series resulting from the 1986 Conference on Science in the National Parks. The 11 refereed papers by 20 contributors were specifically invited by Dr. Wilcox so that they covered many of the interactions among the various disciplines used in wetlands research.

Wilcox's present address is USFWS, National Fisheries Research Center-Great Lakes, 1451 Green Road, Ann Arbor, MI 48105.

**

From David Manski, at Cape Cod NS, comes word of a new USFS publication of possible interest to **Park Science** readers. **Management of Amphibians, Reptiles, and Small Mammals in North America** is the Proceedings of a July 1988 symposium held in Flagstaff, AZ. The 450+ page document ranges from the overarching general (Historical Perspective and Objectives, and The Need for an Environmental Attitude) to the extremely specific (e.g. The Herpetofaunal Community of Temporary Ponds in North Florida Sandhills). Writes Manski: "I got my copy free from the USFS, Rocky Mountain Forest and Range Experiment Station, 240 W. Prospect St., Fort Collins, CO 80526-2098."

Wilderness Proceedings

Managing America's Enduring Wilderness Resource documents the proceedings of the conference by the same name held Sept. 11-17, 1989, in Minneapolis and northern Minnesota in commemoration of the 25th anniversary of the 1964 Wilderness Act and establishment of the National Wilderness Preservation System. The book provides a forum for discussion on how best to protect that System through creative management. Most of the conference presentations are included in this 700-page book. Copies can be ordered from University of Minnesota, Distribution Center, 3 Coffey Hall, 1420 Eckles Ave., St. Paul, MN 55108 for \$32.50, including shipping and handling.

Mercury Contamination: Another Threat to the Florida Panther

One of the nation's most critically endangered animals, the Florida panther (*Felis concolor coryi*) is believed to number only 30 to 50 animals in the wild, according to an Endangered Species Technical Bulletin by Dennis Jordan, Florida Panther Coordinator for the USFWS's Florida Cooperative Fish and Wildlife Research Unit.

The bulletin (Feb. 1990, Vol. XV No.2) ascribes the subspecies' decline to habitat loss, a reduction in the prey base, and the killing of panthers by people. But it also notes that recent information indicates an additional serious threat: contamination from mercury, a toxic metal. Extremely high levels of mercury – over 100 parts per million – were found in the liver of a panther that died in the Everglades last summer. Until her death in July 1989, the 4-year-old female (known to researchers as #27) had been radio-tracked by Everglades NP daily for about 15 months.

The current US Food and Drug Administration's action level for mercury in fish is 1.0 ppm; concentrations as high as 4.4 ppm have been documented in largemouth bass (*Micropterus salmoides*) filets from sites in southeast Florida. Samples from one section of Everglades NP exceeded 1.5 ppm.

Concern is focusing on finding the source of the mercury contamination in Florida, where the usual sources (pulp and paper mills, coal-fired power plants, etc.) do not figure. According to Jordan:

"While no generally accepted explanation has surfaced, a hypothesis was suggested in a December 1989 report released by the Technical Subcommittee of the Florida Panther Interagency Committee [on which NPS representatives serve]. Its report suggests that the mercury could be coming from a natural source: the peat and muck soils that are common throughout Florida. These often flooded and highly anaerobic soils provide a suitable environment for the methylation of inorganic mercury.

"Methylmercury, a product primarily of anaerobic bacteria, is the biologically active and toxic form of mercury; inorganic mercury, on the other hand, is considered to be biologically innocuous. The slow oxidation of peat and muck soils by burning, draining, or other disturbances, provides an avenue for methylmercury to enter the food web, where this contaminant accumulates in the predators of aquatic animals. While no research has yet been conducted in Florida to verify this hypothesis, studies in Finland – a country with one-third of its land covered in peat soil – have traced mercury contamination to various types of surface disturbances."

Studies of the remains of #27 and other archived dead panthers have caused the Technical Subcommittee to conclude that mercury contamination of the pan-



The Florida panther once occurred throughout Florida and from eastern Texas or western Louisiana through Arkansas, Mississippi, Alabama, Georgia, and parts of Tennessee and South Carolina. Today it is believed to survive only in remote parts of south Florida.

ther is potentially a serious threat. None of the mercury levels documented in the other dead and live panthers analyzed were as high as those in #27, still some were at levels high enough to be of concern.

The Subcommittee also concluded that the Fakahatchee Strand and East Everglades areas appear to be hot spots for mercury contamination of panthers. The presumed source is the panthers' prey – particularly raccoons, which bioaccumulate mercury through the aquatic food web. Mercury contamination is also suspect as the culprit in the lower reproductive success of female panthers in areas where small prey is the predominant food source.

The Panther Interagency Committee in January 1990 recommended acceleration of the routine testing of panthers in the wild, establishment of an action level of 1.4 ppm for whole blood in panthers, action to

better identify problem areas and contaminated prey resources, and increase of uncontaminated prey through habitat management and harvest regulations. The Committee also recommended screening panthers for other potential pollutants, including other metals, organochlorines, and PCBs, and supporting efforts to identify and rectify the source of mercury contamination.

On May 18, 1990, a newly radio-collared male Florida panther in Everglades NP was found dead from a chest infection, apparently caused by accidental puncture by a stick. The only remaining male in the park is closely related to the only two female panthers.

Stephen Nodvin, who heads the NPS/CPSU at U/ITN, writes from long and intensive experience with long-term research programs. His views on the NPS Global Change initiatives are strongly held and forcefully expressed in an article in the next George Wright Society Forum, Vol. VII No. 2, scheduled for publication prior to the Nov. 12-17 Conference on Research in the National Parks and Equivalent Reserves, El Paso, TX.

Natural Resource Management At Colonial National Historical Park

By Chuck Rafkind

Colonial National Historical Park (NHP), established in 1930 to preserve the historic resources of Jamestown Island and Yorktown Battlefield, also possesses significant natural resources – worthy of an active natural resource management program. These include extensive tidal and non-tidal wetlands (about 2,000 acres), forest (nearly 8,000 acres), and open fields (about 1,000 acres); 40 miles of streams and James and York River shorelines, and rare, threatened and endangered (RT&E) flora and fauna. Two sizeable units comprise the park: Jamestown Island (1,500 acres) and Yorktown Battlefield (4,300). The units are connected by a 23-mile parkway (3,600), and there are four small, noncontiguous areas: the Cape Henry Memorial, Swann's Point, Green Spring Plantation, and Tindall's Point. Most of the park lies adjacent to the James or York rivers.

In addition, various cultural resource activities involve natural resource processes and techniques. In the light of all this, the park has joined with several outside organizations to conduct in-park research aimed at insuring protection and proper management. These include Virginia's Water Quality Board, Department of Game and Inland Fisheries, Natural Heritage Program, and Department of Forestry; the US Geological Survey, the US Soil and Conservation Service, the USFWS, Virginia Institute of Marine Science, the College of William and Mary, and Hampton University.

With NPS Regional science and Air Quality Division assistance, we are developing a management plan that describes the park's air quality related values and recommends proposals for monitoring of ozone, sulfur dioxide and visibility; acid deposition and its impacts of park structures, vegetation and aquatic environment; and air pollution impact on vegetation. An air quality bio-monitoring program will begin in 1991.

Erosion Control

Personnel from all park divisions have helped design and implement management actions to control erosion on numerous informal trails along the Yorktown bluffs. These bluffs contain the remains of the British (1781) and Civil War earthworks. Trails connecting the bluff and the river have developed serious erosion problems from social usage, combined with the natural sloughing action of the bluffs. Management actions emphasize the use of natural vegetation barriers, including the planting of native bushes, no-cut zones for adjoining open fields, repairing and expanding present fencing and signing. Interpretive actions will include on-site messages, new exhibits, public service announcements to local TV and radio stations, press releases to local and regional newspapers, and orientation for park employees. Also planned is social science research to determine who the trail users are and what are their needs.

A fire management plan emphasizes suppression of fires on park lands and stresses improved coordination with adjoining fire fighting organizations.

The park is working with the State Forester, the Agricultural Extension Agent, and the new Regional Soil Conservationist on a plan for environmentally and economically sound management of the extensive open fields in the park. Erosion control, weed control, forestry practices, alternate mowing regimes, farming,



This distinctive art was created by Yorktown District Interpreter Doug Thompson, to be used as the cover for the park's Resource Management Plan. The design integrates the significant cultural and natural resources of Jamestown Island and Yorktown Battlefield.

water quality management, all are being examined.

A change in the mowing regimes of open fields around Yorktown Battlefield and Colonial Parkway has meant that a number of intensively mowed fields now will be maintained as tall grass fields. It is expected that this will help reduce the number of illegal paths along the Yorktown Bluffs and earthworks. Some fields will be mowed only once a year. Across one field, a path will be mowed to permit easy visitor access from the Yorktown Visitor Center to British Redoubt #9. The mowed path can be changed periodically to limit impact to any one area of the field. Another expected bonus from curtailed mowing will be the abundance of wildflowers it will allow. This selected mowing regime, subject to adjustment, may be extended along the 23-mile Colonial Parkway, providing improved erosion control along the James and York rivers, which flow into Chesapeake Bay.

RT&E Flora and Fauna Survey

The State of Virginia's Natural Heritage Program is conducting an RT&E flora, fauna, and critical natural community survey of all NPS areas in the state. The data thus gathered will aid park planning and management efforts to preserve biological diversity. Also the

study will recommend guidelines for management of the RT&E species and critical habitats of the park. Next to Shenandoah NP, Colonial has the highest number of RT&E species of any NPS site in Virginia.

The Cartographic Computation Lab at NC/State/U is assisting the park in developing a Geographic Information System. Aerial (winter, true color) photographs taken in 1989 are being interpreted and digitized in developing the following themes at a scale of 1:12,000: Current vegetation, wetlands, streams, ponds, earthworks, roads and trails, and adjoining land ownership use types (residential, military, commercial).

These data bases are being used to (1) identify fire management units and prepare fire fuel and National Fire Danger Rating System models, (2) compare historic and current vegetation patterns, (3) prepare park boundary maps delineating adjoining lands that could be developed under the Chesapeake Bay regulations and their impact on the park viewshed, and (4) develop environmental assessments and aid in the review of adjoining land use proposals.

Water Resources Management Plan

We are working with the Regional Chief Scientist,

Vegetation Management in Great Basin NP

By Raymond Jandl, Lee Eddleman, William Brock and Boyd Byelich

The Great Basin province is a mixture of high desert basins alternating with a series of nearly 200 isolated, long, narrow, north-south oriented mountain ranges created by major block faulting. Great Basin NP (GRBA), in the South Snake Range of east-central Nevada, rises nearly 8,000 feet from the valley floor to the top of 13,063 foot Wheeler Peak. It contains a diverse flora, ranging from desert to arctic alpine above tree line.

Many of the potential natural communities found in the Great Basin Province were a complex of plant community types, the result of disturbances such as fire and drought. These events were cyclical, with natural successions occurring during interims that varied from 40 to more than 100 years, depending on the community. By the early 1880s, livestock grazing was being introduced to the Province on a first-come, first-served basis, with no restrictions to prevent overgrazing. Fire, believed to be a natural component of many of the potential natural communities in the Great Basin Province, was greatly reduced during this period because the fine fuels (grass) needed to carry fire were removed by grazing. Consequently, plants susceptible to fire but not used as livestock forage established and expanded their ranges.

Livestock numbers in Nevada have declined from a high of 1.2 million sheep and 500,000 cattle in 1918 to 93,000 sheep and 383,000 cattle today. The fire-carrying fuels have increased with the decline in livestock numbers and with improved rangeland management. However, a continuing policy of fire suppression has essentially eliminated fire.

Continued from page 16

the NPS Water Resources Division, Virginia Polytechnic Institute, and State University Water Resources Research Center to develop a parkwide water resources management plan. The plan will (1) complete the delineation of park non-tidal wetlands and prepare computerized maps, (2) prepare a hydrological overview of the park, (3) conduct a literature review of research, monitoring, and mitigation actions that cover or impact park lands, (4) review and recommend approaches for the park to interact with present and proposed research, monitoring, and mitigation projects in and adjacent to the park, and (5) review existing baseline data on park water quality, preparing recommendations for additional baseline inventory and monitoring needs for research.

Some of the water quality issues of concern include (1) water quality – groundwater and surface waters, wells, and public water supply systems; (2) erosion and sedimentation problems – involving shorelines, rivers, streams, farming practices, trails, roadway drainages, and urban development; (3) underground storage tanks, septic tanks, and wells, both active and inactive; (4) recreational use and impacts – nature and severity; and (5) determination of actions the park should take under mandates to protect and prevent degradation of park wetlands.

The park faces complex environmental, visitor use, and cultural resource management challenges and we are working to develop an active management program that takes into consideration all the interrelated natural and cultural resources of which we are the stewards.

Rafkind is Natural Resource Specialist at Colonial NHP. He can be reached at FTS 827-8050 or (804) 898-3400.

GRBA was established to illustrate and preserve a portion of the Great Basin physiographic province. GRBA also is charged to provide for continued livestock grazing. Integrating livestock grazing into a preservation management strategy demanded a research study to evaluate the rangeland resources of the South Snake Range, from which a comprehensive range management program will be developed.

In 1988, in cooperation with the Department of Rangeland Resources at Oregon State University, GRBA began a 2-year range resource analysis. This study is also being used to verify, refine, and improve the vegetation classification and mapping effort of the NPS from LANDSAT imagery. Evaluation of rangeland resources includes a survey and description of the present plant communities in the park, analysis of the past status of these communities, and a prediction of future development under various management strategies. Following is a preliminary look at the resource evaluation after the first summer's field season.

Methods

The study area, in the South Snake Range, covers roughly 250,000 acres. Of this, approximately 4,000 acres is private land, 70,000 acres is managed by BLM, 99,000 acres by USFS, and 77,000 acres by NPS.

Reflectance values in four bands from a June 1986 LANDSAT image were used to generate spectrally unique landcover categories for each 30m x 30m area of land (pixel). These landcover categories were the result of an unsupervised classification within the GRASS GIS program. Based on preliminary surveys and observed cover types, a classification by the NPS GIS Division in Denver identified 20 cover types.

From this initial stratification, polygons were identified as potential sampling sites to describe the associated plant communities. A minimum polygon area of 2 ha was the initial criterion established. This was done to minimize the influence of errors either inherent in imagery, induced operationally through data manipulation, or associated with accurately locating uniform areas in the field (Warren et al. 1989). Sampling sites were concentrated on NPS and USFS lands. Within these lands the sites were so distributed that cover types were sampled in each of the major drainages and were proportional to the area occupied by each cover type.

Vegetation descriptions were determined from a 50m x 20m macroplot located within a representative portion of the identified polygon. Each site description included environmental characteristics, species lists and cover, ground cover characteristics, grass and forb production, relative deer and livestock use based on feces occurrences, and tree density, size and age. A total of 104 cores taken from dominant tree species established stand age distribution. Trees were divided into size classes similar to those defined by Blackburn and Tueller (1970) for pinyon and juniper, and by the USFS Ecosystem Classification Handbook (Jensen and Keane, 1987) for conifers and aspen.

Results and Discussion

During the 1989 field season, 50 macroplot sites were visited. Of these, 8 were mountain big sagebrush (*Artemisia tridentata* var. *vaseyana*) with no tree species present, 15 were various densities of pinyon (*Pinus monophylla*) and juniper (*Juniperus osteosperma*), 10 were aspen (*Populus tremuloides*), 6 were other coniferous forest types, and the remainder were meadow and low sage (*Artemisia arbuscula*).

The pinyon juniper cover type occupies 86,540 acres of the project area. Prior to arrival of European man, pinyon and juniper are believed to have been confined to rock outcrops and other areas protected from fire. There, trees were relatively long-lived, but in low densities. Of the 15 pinyon juniper sites evaluated to date, only one was found to be an old mature stand. This was on a steep, south facing limestone slope. Total tree cover was 19 percent. Cores taken from an old mature pinyon and a juniper were estimated at 400 and 470 years, respectively.

The remaining sites are in areas with less adverse conditions. Of the pinyons aged in these sites, no tree was older than 160 years and most averaged less than 100. Thus, pinyon is a relatively recent arrival. The effect of pinyon on site dynamics can be estimated by comparing site conditions among various densities of pinyon cover in these stands. (Table 1). As the density of trees increases toward a closed canopy condition, the species diversity and the percent cover of shrubs, forbs, and grasses declines. By the time pinyon cover reaches 60 percent, total forb, grass and shrub cover has shrunk from 60 percent to less than 3 percent.

Continued on page 18

Table 1. Mean tree cover, cover and number of species of shrubs, forbs, and grasses, and deer pellet groups per macroplot for several plant cover types at Great Basin NP. (T = trace).

Cover Type	Percent cover				Number species				deer pellet groups 100 m ²
	tree	shrub	forb	grass	shrub	forb	grass		
Sagebrush	0	33	13	17	6	19	7	69	
Pinyon (old stand)	19	18	T	0	3	1	0	0	
Sagebrush with scattered pinyon	4	21	9	21	6	20	9	15	
Pinyon (young stands)									
Low density	20	23	5	7	6	13	6	48	
Moderate density	41	6	2	2	4	10	4	6	
High density	60	1	T	1	5	8	5	7	
Aspen	81	5	10	3	3	11	4	25	
Conifer									
Engelmann spruce	46	2	T	T	1	3	1	1	
Limber pine	25	23	7	2	4	1	3	5	
Douglas-fir	58	7	T	T	3	3	3	8	

Peregrine Falcon Research in the Yukon-Charley Rivers National Preserve, Alaska

By Skip Ambrose and Steve Ulvi

The decline of the peregrine falcon came to symbolize the devastating effects of some man-made chemicals on the environment. Likewise, peregrines have become a showcase of man's ability to protect and recover endangered species. While not all species will be so responsive to human management efforts, the recovery of the peregrine falcon is a genuine success story. Recent issues of *Park Science* included several articles on surveys and hacking efforts in parks in the lower 48 states. In Alaska, where peregrines declined to approximately 30 percent of their historical (pre-DDT) levels, there has never been any nest manipulations or hacking. Consequently, peregrine populations in Alaska offer a unique opportunity to study the natural recovery of an endangered species without human intervention. The Yukon-Charley Rivers National Preserve (YUCH) in particular is invaluable for such study because of the historical information available and many years of intensive survey and banding studies.

Three subspecies of peregrine falcons occur in

Alaska: the Arctic Peregrine Falcon (*Falco peregrinus tundrius*) inhabits the northern tundra region of the state, the American Peregrine Falcon (*F. p. anatum*) occurs in the forested interior, and the Peale's Peregrine Falcon (*F. p. pealei*) occurs in the coastal regions of the Aleutian Islands, Gulf of Alaska and southeast Alaska. Both the Arctic and American subspecies are highly migratory, wintering as far south as Brazil and Argentina. The Peale's Peregrine Falcon is for the most part a year-round resident within its range, but some movement along the west coast of Canada and the United States occurs. The Arctic subspecies is currently listed as "threatened" and the American subspecies is listed as "endangered." The Peale's subspecies is not considered threatened or endangered.

The decline of peregrine falcons in Alaska may have begun as early as the 1950s following initial use of DDT. Surveys of the past three years recorded numbers over twice those observed in the early surveys, and investigators now believe the very early surveys either missed birds, due to timing of the surveys, or the population was already declining and researchers had no

way of knowing this.

Research on peregrines in Alaska has focused on the listed Arctic and American subspecies, and the YUCH has been a principal study area in interior Alaska. As early as 1898, biological surveys in this area documented peregrines nesting on the cliffs that occur along the Yukon River, and in the 1950s, Dr. Tom Cade (1960) surveyed sections of the river. Because of the historical information available, this section of the Yukon River was selected by the Alaska Peregrine Falcon Team as an index population area for monitoring and measuring recovery. Since 1979, intensive surveys, banding and other research have been ongoing in the Preserve. With information dating back to the late 1800s, and continuous intensive research beginning in the late 1970s, few areas offer such an opportunity for research and monitoring.

Surveys in Alaska

Peregrine falcons arrive in interior Alaska about mid-April. Males and females apparently migrate separately but arrive at the nest site within days of each

Great Basin NP Vegetation Management (Continued from page 17)

Deer use based on the presence of pellets also declines substantially as the density of pinyon approaches 40 percent.

Examination of size class distributions (Figure 1) within the low (10 to 25% cover), moderate (26 to 50% cover), and high (>50% cover) pinyon density groups

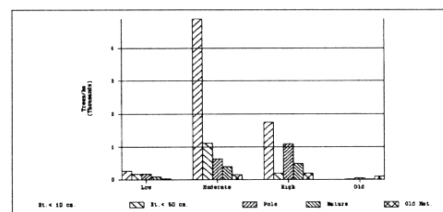


Figure 1. Pinyon size classes within the four pinyon density classes.

shows a large number of small plants in the moderate density class. These are the source of future mature trees, which eventually will dominate the sites and outcompete present vegetation. Since the survival rate of pinyons less than 0.5 m tall is relatively high unless killed by fire, this suggests continued increase in density and cover of pinyon on the 37,000 acres of moderate density pinyon sites. Any increase in pinyon can be expected to be accompanied by further loss of diversity and cover of associated forbs and grasses. The area most heavily used by deer would be further reduced.

The aspen cover type occupies 10,150 acres. Aspen are frequently a temporary, dominant, seral species in a variety of climax conifer associations following severe disturbance such as fire (Mueggler and Campbell 1986). Examination of the size class distributions (Figure 2) shows a large number of saplings (<1.5 m tall), pole (<12.5 cm dbh and >1.5 m tall), and mature (12.5 to 35 cm dbh) trees but no large mature trees (>35 cm dbh). Average age of trees in the pole size class was 74 years and in the mature size class, 107 years. Seedling and sapling white fir (*Abies concolor*), and limber pine (*Pinus flexilis*) are found in these stands. These small conifers averaged 50 years old. The presence of small conifers in the aspen commu-

nities suggests that aspen in most of this area is a seral species having become established 90 to 120 years ago following a disturbance of some sort. Fire scars on standing trees and charcoal found on these sites indicate fire occurrences. Fire suppression has been shown to contribute to a reduction of regeneration in aspen communities. Thus, under present management policies, these stands are expected to become dominated by conifers with a loss of aspen.

Conifer communities occupy 25,880 acres. They appear to be long-lived communities. Recruitment in the limber pine stands appears to be small, but survivability is high, so there are a number of large specimens (Figure 3). Douglas-fir (*Pseudotsuga menziesii*) and Engelmann spruce (*Picea engelmannii*) appear to have a greater rate of establishment but a lower sur-

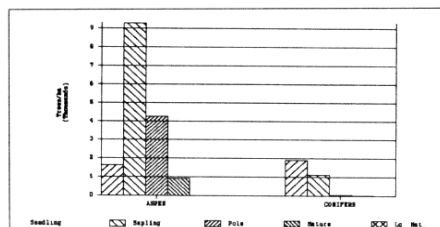


Figure 2. Size class distribution of aspen and conifers in the aspen cover type.

vival percentage, resulting in a similar number of large trees compared to limber pine. Maximum ages of the large trees were at least 381, 372, and 237 years for the Engelmann spruce, limber pine, and Douglas-fir, respectively. (Larger trees were present but equipment limitations prevented sampling of trees larger than 60 cm dbh). It appears these communities have changed relatively little since arrival of European man. With no disturbance, these stands probably will change little in the future except for an increased build-up of dead and down wood.

Summary

Examination of the rangeland management program at GRBA has developed awareness that live-

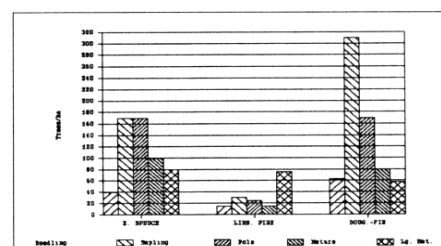


Figure 3. Size class distribution of the dominant conifer in the Engelmann spruce, limber pine, and Douglas-fir cover types.

stock management alone will not overcome the major vegetational changes occurring in the park. These changes were set in motion by humans decades ago, through overgrazing and the fuel reduction it causes. People continue to affect the dynamics of plant communities through suppression of naturally occurring fires. Fire management at GRVA is currently being reviewed. Refinement of this program is dependent on understanding today's plant communities and the historic role of fire.

Preliminary evaluation of GRBA's plant communities suggests that alternative management options will become drastically diminished if present successional trends continue. Associated with the on-going change is a reduction of vegetation diversity and a corresponding decrease in wildlife abundance.

Jaindl and Eddleman are Research Associate and Associate Professor at OSU; Brock and Byelich are the Resource Management Specialist and Range Technician at GRBA.

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Adult female feeds her young. Notice the FWS band and black aluminum band with alpha-numeric code.

other. Breeding activity is initiated immediately, and the first eggs are laid by early May. Our first surveys, to determine nest territory occupancy and the number of pairs attempting to breed, begin about two weeks after the river ice breaks up – usually between May 5 and May 15. Large ice floes, trees and debris congest the river and make travel dangerous for about two weeks after breakup, so surveys generally start about May 25. Eggs hatch between early and mid-June, and we plan our second survey to correspond with the optimum banding age, about three weeks. Our second surveys generally occur during the first two weeks of July.

A 20-foot river boat with a 90 horsepower outboard is used to survey the 165 mile stretch of the Yukon River between the Alaska-Yukon Territory border and Circle, Alaska. Inflatable rafts, flown to the headwaters in helicopters or small fixed-wing aircraft, are used to survey the tributary rivers. Ground surveys, as opposed to aircraft surveys, are essential for accurate results.

Other research projects concerning peregrine falcons or their prey also have been conducted during the past 10 years. Trapping adult falcons to determine dispersal, movement and mortality was initiated in 1981. Beginning in 1986, all young and adults trapped were banded with alpha-numeric coded color leg bands in addition to the standard USFWS leg band. Using high-powered spotting scopes, we are able to identify individual falcons in subsequent years without the need to trap and handle the birds. Pesticide studies on peregrine eggs were conducted in 1984 and again in 1989. Prey remains are collected from occupied eyries every year for identification, and in 1985 and 1986 a study on

prey selection was conducted. A limited home range study using radio-telemetry was undertaken in 1986.

The wide variety of survey techniques employed in the past, and the resulting difficulty in analyzing survey data, led the USFWS and others to develop standardized techniques for surveys and data collection in Alaska. These require at least two trips through study areas, one during incubation and another when the young are three to four weeks old. At least four hours of observation at any known or suspected nest site is necessary before a determination of the status of that site can be made. Finally, all survey data are recorded on a Raptor Observation Record Card developed by the USFWS for raptor surveys. A computerized database was developed in conjunction with the card facilities data entry and analysis. This card and database was further refined in cooperation with NPS scientists in other regions and is now used in several other states.

Results of Falcon Research in the Preserve

The earliest surveys along the Yukon River in the Preserve area documented 15 to 16 pairs per year (Bishop 1900, Cade 1960). In 1966, 15 pairs and 27 young were observed (Cade et al. 1968). The lowest recorded level was in 1973 when Ritchie (1976) observed 11 pairs, 1 single adult and 16 young. The population remained near this level until 1978 when the first increases were detected. That year, 16 pairs, 3 single adults and 28 young were seen. The population has continued to increase through 1989 when 33 pairs, 2 single adults and 54 young were seen (Ambrose et al. 1988). Surveys along the major tributaries such as the Charley, Kandik, Nation and Tatonduk rivers docu-

The Yukon-Charley Rivers National Preserve

The Yukon-Charley Rivers National Preserve was established, in part, to ensure the protection of habitat for and populations of all fish and wildlife including the endangered American Peregrine Falcon.

This stretch of the Yukon River offers abundant cliffs and highly diverse lowland topography and vegetation within relatively short distances of nesting territories. The Yukon River valley is composed of low, rounded benches and ridges trending southwest to northeast and averages 2-3 miles in width.

The preserve lies within a climatic division of Alaska known as the interior basin. The mountains to the north and south tend to block the moderating influences of oceanic air masses, resulting in extremely low temperatures in the lengthy winter and high temperatures and low precipitation during the summers.

The complex geologic structure, severe semi-arid continental climate, frequent occurrence of wildfire, and discontinuous permafrost soils have interacted over time to create a complex mosaic of taiga and upland tundra biotic communities. The present diversity of subarctic flora and fauna reflect this interplay of physical processes and the near absence of late Pleistocene glaciation.

These vegetative communities experience annual natural perturbations such as ice-scouring, flooding, frequent wildfire, and insect infestations that result in a dynamic vegetative mosaic. In turn these diverse and productive seral stages provide excellent habitat for birds returning to breed in the summer. Only two dozen birds are considered resident in this area but with the onset of the intense subarctic spring nearly 160 species (including 17 raptors) are known to breed here.

For many raptor-watchers and biologists raised in the post-World War II era of widespread pesticide use and its dire consequences, the opportunity to observe healthy populations of American Peregrine Falcons in a wildland setting is only a dream. Rugged bluffs and layered outcrops tower above turbid waters along the heavily forested Yukon River corridor. This is a time-worn landscape that is by any measure outstanding peregrine habitat. The vast proportions of the country carved by "The Great River" stretch the human imagination and seem a perfect backdrop for the whistling of sickle-wings in determined stoops.

mented similar increases. In recent years, it has not been unusual to find 50 or more occupied sites and 80 to 100 young. A crude estimate of the total population in the preserve is 60 to 70 pairs, and possibly more in the highest years.

Cade (1960) estimated the interior Alaska peregrine population at 250 pairs. Recent surveys throughout the interior suggest that pre-DDT population number may have been higher than Cade's figure. The increases of the peregrine population during the past 10 years have been truly remarkable.

With a sizeable and healthy population, we were able to undertake research projects that were fundamental to understanding the biology of peregrine falcons. Some of these projects were not

Continued on page 20

Army Chopper Rescues Falcon Counters

Five volunteer peregrine falcon counters, who had been manning sites on both sides of the Port Mansfield Channel (about 60 miles north of the Padre Island National Seashore), had to be airlifted out of their soggy sites in early June when the rains set in before their spring survey was completed.

The group, all of whom are experts in handling birds of prey, tried to continue their survey throughout the storms, but the attempt proved futile. They were sinking into the saturated sands and their equipment was too heavy to move under such conditions. The Corpus Christi Army Depot chopper had to make four trips to get the surveyers and their gear to high, dry land.

The survey effort is funded by the U.S. Army and collects information on the peregrine falcons migrating through this area. In spring, the birds are returning from either Latin America or Mexico, enroute to Alaska, Canada or Greenland. This year the group encountered 125 birds, which is about average.

The program is "permitted" through the USFWS, the NPS, and the University of Texas. It began in 1978. This year's team was headed by Tom Maetchle, who is working on a Doctorate at Boise State. "In the fall," he said, "we might find as many as 400 falcons migrating through here. The birds are younger, less experienced - 60 to 70 percent of them won't live through their first year." The average life span averages 10 years - if the birds make it through their first year.

The team covers an area 40 miles long by 12 miles wide. The birds are banded, blood sampled, measured, and released. Surveyors have found that birds who migrate from the farthest north, travel the farthest south. They also have found that the levels of pesticides have been decreasing in certain parts of the world.

Peregrine Research (Continued)

feasible, biologically or politically, in any other area of the United States. Over 1500 nestlings have been banded in interior Alaska since 1979, many of these in the Yukon-Charley Rivers National Preserve. Close to 100 recoveries outside Alaska have revealed major migration routes, staging areas and wintering areas. Given the changing nature of habitats all over the world and the continued use of harmful pollutants in many areas, this information is critical to management of the species.

In addition to recoveries outside Alaska, nearly 200 recoveries in the state have resulted from our adult trapping effort. This trapping has allowed us to determine dispersal patterns from natal areas, age of first breeding, turnover of adults at nest sites, movement of breeding adults between nest territories, and adult mortality. Age of first breeding appears to be related to density of the population and available nest sites; females tend to disperse farther than males (mean of 75 miles for female versus 43 miles for males) (Ambrose and Riddle 1988). More importantly, with this understanding of age of first breeding (in both a depressed and recovered population), breeding success of different aged birds, and normal dispersal distances, we can lend insight into recovery potential and timing in other areas.

Future Management Considerations

The peregrine population in the Preserve appears to be nearing full recovery. Peregrines in Alaska will likely be considered for delisting in the next few years. Continuing pesticide use and habitat changes along migra-



Volunteer Scott Francis rests on his ATV in between trips to drier land. The air support saved the falcon team days of work in moving their equipment via ATVs through miles of sopping sand. (U.S. Army Photo by Francoise Cymes).

tion routes and in wintering areas, and their unknown cumulative effects, make future monitoring critical. Expansion of research and inventory and monitoring efforts on this unique population will provide the opportunity to assess and monitor several aspects of the biodiversity of these river ecosystems. Such research should allow us to measure to some degree the effects of pollutants and habitat alteration outside the United States. The peregrine is an effective ecological generalist and as such is an excellent indicator species, reflecting subtle changes in the environment.

Ambrose is Project Leader for the Endangered Species office of the USFWS in Fairbanks, Alaska, and the Recovery Team Leader of the Peregrine Falcon Recovery Team, Alaska Population. Ulvi is Resource Management Specialist for the Yukon-Charley Rivers National Preserve.

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ROMO Raptor Survey

All Park areas in the Rocky Mountain Region known to have peregrine falcons are in the midst of raptor surveys. One goal is to survey all of the suitable habitat for peregrine falcons by fall, 1991. NPS is co-operating with USFWS in a peregrine prey contamination study designed to follow-up a similar study completed 10 years earlier. The results should give insight into the peregrines' recent population increase and may provide clues as to why certain segments of the population continue to experience poor reproductive success. The NPS has co-operated with USFWS in a color-banding protocol for the western U.S., consistent with the protocol for Alaska, Canada, and Greenland. The bands, easy to read from a distance, will provide more information with less handling of the birds.

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Monitoring Case Studies Selected

By Gary E. Davis

Tom Wilson's cartoon character Ziggy found the park "CLOSED FOR INVENTORY" in his cartoon that ran on Sunday, July 8, 1990. Wilson's art does more than imitate life, it foreshadows it. With existing operating funds, the NPS is faced with a Hobson's choice of closing the parks to inventory and monitor them or literally running them into the ground.

How much is needed to inventory and monitor natural resources? Pro-rating from prototype programs like Channel Islands and Shenandoah NPs to account for smaller and larger parks, it appears that the NPS needs about \$200 million a year. Is it worth the investment? How can we find out? Funding a few model programs and gaining firsthand experience is probably the best way, but it will take 10-15 years to reap the real benefits. A much quicker, but less certain, way is to examine case histories of long-term studies that simulate monitoring.

Heeding the adage that those who do not learn from their history are doomed to repeat it, the NPS Inventory & Monitoring Steering Committee commissioned a series of case studies to evaluate cost estimates and to develop confidence in the value of monitoring programs. A group of 19 superintendents and scientists met at Channel Islands NP July 24-27, 1990 and selected 15 examples of major natural resource issues involving monitoring or long-term research. Case studies of the selected issues will be used to determine the relative values and costs of resource monitoring and long-term research for park management.

The Regional Chief Scientists and about 50 senior managers and field scientists nominated nearly 100 candidate cases last spring. We organized those into issue categories identified in the 1987 GAO report on "Threats to the Nation's Parks" to structure the workshop and help assure a representative sample of issues in the final selection. Each workshop participant introduced the nominated cases in one category and moderated the ensuing discussion. After nearly two days of presentations and discussion, the group agreed on 36 cases, all of which addressed major

Case Studies Selected

to Evaluate Monitoring Programs

ISSUE: THREAT TO ECOSYSTEM INTEGRITY – AESTHETIC DEGRADATION

Adjacent Community Growth & Development – SAGU
Fire Research & Management – YOSE & SEKI

Predator/Prey Relationships and Ungulate Herbivory – ISRO

Saguaro Cactus Dynamics – SAGU

ISSUE: ALTERATION OF WATER QUALITY OR QUANTITY

Devil's Hole Pupfish/Water Rights – DEVA

Water Diversion – EVER

Water Quality – MACA

ISSUE: CONSUMPTION OF RESOURCES

Native Fish Exploitation (Cutthroat Trout) – YELL

Fisheries Management – EVER

ISSUE: IMPACT OF ALIEN SPECIES

Biological Invasions – HALE & HAVO

Goat Management – OLYM

ISSUE: PHYSICAL IMPACTS OF VISITORS

Wilderness Research & Management – YOSE & SEKI

ISSUE: AIR POLLUTION

WHITEX/Navajo Power Plant – GRCA

ISSUE: PARK OPERATIONS

Rare Plant Management – INDU

River Use Management – OZAR

DEVA = Death Valley NP; SAGU = Saguaro NP; YOSE = Yosemite NP; SEKI = Sequoia/Kings Canyon NPs; ISRO = Isle Royale NP; EVER = Everglades NP; MACA = Mammoth Cave NP; YELL = Yellowstone NP; HALE = Haleakala NP; HAVO = Hawaii Volcanoes NP; OLYM = Olympic NP; GRCA = Grand Canyon NP; INDU = Indiana Dunes NP; and OZAR = Ozark NP

The July-August issue of *BioScience* is devoted to discussions of long-term ecological research.

issues, used or needed long-term data sets, and had reached a conclusion. The 15 best cases also showed

some universality in setting precedents for other areas, represented programmatic rather than ad hoc approaches to monitoring, and demonstrated an NPS management commitment to continued monitoring.

The final list contains examples of all 7 major categories of resource issues from 15 parks in 5 regions. The product of the workshop is a document that defines the 15 best cases and describes the contents of each case study. The studies are scheduled to be conducted in FY91 by nationally recognized experts on the issues. Each study will present a history of the case, describe the monitoring program (or long-term research), define the issues addressed, and describe the role of monitoring in determining how issues were perceived, approached, resolved, and evaluated. The relative costs and values of long-term monitoring (or research) will be analyzed and presented at the conclusion of each case study. The case studies will be presented at a national symposium, and compiled, analyzed, and published.

A valuable byproduct of the workshop was the camaraderie and communication that developed among a diverse group of park managers and scientists as they struggled together with a common challenge. The group represented 10 parks, 7 regional offices, and 2 Washington office divisions, and came from many different professional backgrounds. The workshop was conceived and conducted by research scientists Gary E. Davis and William L. Halvorson and superintendent C. Mack Shaver, Channel Islands NP. Participants were Jim Carrico (Big Bend NP), Jay Goldsmith (Western Region), Ron Hiebert (Midwest Region), Gary Johnston (WASO Vegetation & Wildlife), Randy Jones (Olympic NP), Lloyd Loope (Haleakala NP), Cliff Martinka (Glacier NP), Dave Mihalic (Mammoth Cave NP), Bill Paleck (Saguaro NP), Stan Ponce (WASO Water Resources), Mike Soukup (Everglades NP), Brian Underwood (Mid & North Atlantic Regions), John Varley (Yellowstone NP), Jan VanWagtendonk (Yosemite), Richard Whitman (Indiana Dunes NL), Ro Wauer, retired NPS, was an active observer from the National Academy of Sciences panel reviewing NPS science programs.

A Pertinent Letter from Alaska?

The word "inventory" is a downer. To inventory furniture and equipment against property lists is biologically sterile and intellectually boring unless something expensive turns up missing – resulting in sheer terror (another negative).

The sign in the store window, "Closed for Inventory," means tediously counting stock down to the last nut and bolt, usually so it can be taxed (also an unpleasantry).

Once, NPS tried Resource Basic Inventory (RBI), in an attempt to find out everything about everything in a park. That made even the strongest scientists blanch and it curled the upper lips of superintendents and rangers. I know. I was there!

Monitoring, however, is the life blood of an agency. We monitor animal populations, wildland fires, bear/human interactions, livestock grazing, weather conditions, visitor statistics, sewage treatments, pesticide uses, law violations, salaries and leave times, ad infinitum. Data gathering is necessary for monitoring, but when was the last time you heard it called "inventory"? Of 183 Areas of Expertise listed in the NPS Natural

Resources Personnel Directory (printed in 1988), only once – in "Baseline Inventory and Monitoring," was the word "inventory" included.

Management, on the other hand, was mentioned 37 times, which shows where the money is. And of 624 people in the directory, only 14 mentioned inventorying as one of their specialties.

The problem remains: We badly need Inventory and Monitoring and we aren't getting it. Blaming part of the problem on a word may seem simplistic, but I'm not sure it is. The primary reason I&M has not worked, in my opinion, is that it is aimed at the future, while we want – or have – to focus on today's problems and needs. The recent revival of interest in I&M (NPS-75) is an attempt to break away from the work-a-day world to gather data about baselines and changes – needed for future decisions.

Is that important? How else can we determine what we have, and manage to leave it unimpaired for generations to come, while at the same time providing for this enjoyment?

But I repeat, the name doesn't help. "Inventory," with

its suggestion of trying to find out *everything*, is discouraging. Do I have an alternative? Does Alaska have snow and ice?

My solution is: Just call it "natural resource monitoring." Natural Resource Monitoring should be a full partner with Natural Resource Research and Natural Resource Management. It would be the repositor and collator for the wealth of information obtained by Research and Management, would ask those functions to gather whenever possible data not needed for immediate problem solving (against future needs), and be staffed and equipped to get additional data.

What's in a name? Lots! For example, NPS employees rarely talk about "working for a government bureau," or call themselves "bureaucrats." What chance would an Edsel have today, even without the toilet seat, in a world full of Cougars, Cavaliers, Corscas, Conquests, or even my own little Dodge Colt (which is really a Mitsubishi)? How about the Peacekeeper Missiles and Freedom Fighters of the last Administration? We really *need* Inventory and Monitoring, so let's drop the negative word, accentuate the positive one, and get on with the job.

Al Lovaas

Chief Scientist, NPS Alaska Region

Arctic Steppe: Snapshot of the Past or Glimpse of the Future?

By Sara Wesser and Penny Knuckles

When continental ice sheets blanketed much of North America, land was exposed connecting Siberia and Alaska, forming an area known as Beringia. Paradoxically, Beringia itself remained unglaciated and may have been covered with vast areas of steppe, a vegetation type characterized by grasses and low shrubs very different from the present widespread forest and tundra of the region. Today, a few geographically isolated plant communities of this type survive only in Siberia and Yukon-Charley Rivers National Preserve in Alaska. High above the waters of the Yukon River, arctic steppe communities contrasting distinctly with the surrounding taiga forest find refuge on a few steep, south-facing river bluffs near the border between Alaska and Canada.

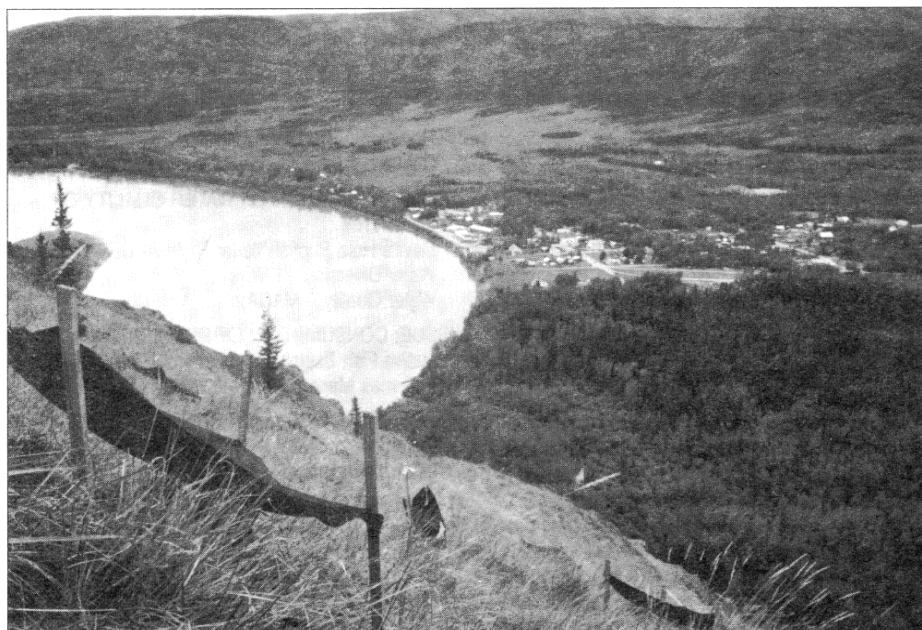
A chain of ecological islands strung along the Yukon, the steep bluffs above the river preserve these unique assemblages of plants. Endemic species found on one bluff are not always present on the next a few miles away, but other species are common to all. Four taxa are candidates for federal listing as endangered species, while the population levels and distribution of several others is too poorly known to justify classification at this time. Disjunct populations of mosses and lichens also occur, their nearest relatives 2,000 miles away in Siberia.

This persistence of a plant community prevalent during the Pleistocene on today's dry south-facing slopes is puzzling. What conditions have allowed the survival of arctic steppe and what conditions limit its present distribution? There is evidence that today's steppe species are at the limit of their ecological and distributional ranges. Warm, treeless islands in a sea of cool, mesic forest, arctic steppe intergrades with the aspen and tundra. What factors control this interface? More importantly, how do fluctuations in climate affect the distribution of steppe species? These questions prompted the research that we describe.

The mere logistics of studying these steep, south-facing bluffs challenged both researcher and park manager. Hot daily climbs lugging water and equipment up unstable scree were never merely routine, since bears frequent the same slopes. Mini-landslides could send the objects of study tumbling downhill. Eroded trails appeared like magic. American peregrine falcons, an endangered species, and other raptors oversaw projects from their nest sites. Over-zealous collectors, while not yet a problem, could have decimated rare plant species. Logistics were complex, since the study site required boats for access during high water.

Despite these factors, Eagle Bluff was chosen as a study site. Twelve miles upriver outside the preserve boundary, it is representative of arctic steppe on other bluffs within the preserve. While the site's location adjacent to the town of Eagle had its advantages, it was still necessary to cross a large creek via hip waders or an exciting cable ride. The peregrines nesting on the opposite side of the bluff are somewhat habituated to human use. Fortunately, a trail to the study site already existed.

I, Sara Wesser, as principal investigator, recall feeling a bit daunted by my first view of Eagle Bluff in 1987 as I rounded a bend in the Taylor Highway. I remember



Eagle Bluff Study Site (Eagle is in background) Shade treatment in foreground.

slowing my vehicle to a halt as my eyes traversed the 2000 foot rise from the Yukon River to the top. After an initial feeling of dismay – surely the bluff supporting the arctic steppe community was not quite so steep nor so high! – those doubts were put aside by the thought that I was at Eagle Bluff precisely because that imposing slope provided the perfect environment for an arctic steppe community. The next two field seasons focused on analyzing the environmental conditions of the bluffs that allow the steppe communities to survive.

The goal was to describe the abiotic and biotic factors that control species distribution across the transition between steppe and forest. These questions were addressed using correlative methods to show relationships between vegetation and environment and experimentation to test predictions from correlative models and establish the causal pathways of species' response to environment.

A correlative model was developed to portray explicit hypotheses about vegetation-environment relationships. To do this environmental variables were measured and percent cover of all understory species present was sampled in 70 plots. Environmental variables included the extent of tree cover (an estimator of radiation below the canopy), litter, slope, aspect, soil temperature and moisture, pH, organic matter and disturbance. Among the measured variables, soil moisture and the extent of tree cover most strongly controlled the transition in species composition. It was assumed that understory species responded most strongly to the influence exerted by tree cover on radiation below the canopy. Soil moisture controlled the tree cover itself.

If species are distributed according to their physiological optima (that is, where their growth would be best in the absence of biological factors such as competition or herbivory which may reduce physiologically potential growth and survival), we would expect each

species to be most robust in the light and moisture environment most similar to its native habitat. Forest species would perform best in the low light and high soil moisture characteristics of forests, and steppe species in the high light and low soil moisture of steppe. However, species are not always distributed this way. Biotic factors (e.g., competition for limiting resources) eliminate species from sites that are otherwise more favorable for their growth. An alternative explanation of the results of the correlative model that was developed: steppe species may tolerate aridity better than forest species but are excluded from the more mesic and presumably more favorable conditions inhabited by forests today due to low light conditions.

These hypotheses were tested in experiments with two forest natives and two steppe natives transplanted into the steppe community. To test for the effects of light, plants were either shaded to simulate the low light levels of the forest, or left unshaded in the steppe's high light environment. To test for the effects of soil moisture, plants were either watered daily to simulate moist forest soil conditions or were given no supplemental water in the dry steppe. The results suggested steppe species are eliminated from forest areas primarily by competition for light, but revealed differences in the relative importance of environmental factors among species. The forest taxa appeared to be restricted to their observed range because of intolerance for the high light and dry soil of steppe. Growth of steppe taxa would be improved in the mesic conditions of forest if they were not limited by the forest's low light.

If arctic steppe provides a snapshot of environmental conditions 12,000 years ago, can changes in its distribution indicate global climate trends in the future? Since steppe communities span two ecotones (steppe-forest and steppe-tundra), minute variations in climate could cause observable changes in the vegetation of steep south-facing bluffs. The distribution of

Effects of Global Warming on Freshwater Ecosystems

By Jerome E. Freilich and G. Wayne Minshall

The idea of global climate change is mostly speculation at this point – a prediction founded on some still fairly shaky evidence. Yet it would be unconscionable not to give the possibility serious consideration. We offer these thoughts on global warming and its effect on freshwater ecosystems while at the same time wishing to avoid proposing dire consequences based on too little data, putting too much faith in preliminary scenarios or failing to consider other plausible alternatives. Our comments are based on a symposium, "Troubled Waters of the Greenhouse Earth: Climate Change, Water Resources and Freshwater Ecosystems," held at Virginia Tech in May 1990, the results of which will be published by fall of 1991.

Estimates predicting a doubling of atmospheric CO₂ levels within the next 100-150 years are today almost universally accepted (Schneider 1989). If this occurs, global average temperatures may increase up to 5.5°C, and precipitation will increase by 7-11 percent. In general, the central parts of the continents will get warmer and drier in summer. The oceans will warm more slowly than the continents, while the polar regions will warm more than the equator. The largest temperature changes will occur in the fall and winter seasons at the high latitudes of both hemispheres.

An initial response to warming will be increased levels of methane derived from bacterial metabolism in tundra and boreal wetland ecosystems during summer months. The huge expanse of Canadian and Siberian tundra will provide large amounts of this greenhouse gas to the atmosphere, compounding the greenhouse effect. As warming proceeds, melting will lower the permafrost layer, further increasing the release of methane. This effect is fairly easy to project because arctic ecosystems are relatively simple. In temperate and tropical areas, effects will be no less significant, just harder to estimate.

All global processes are linked, so terrestrial events will have effects on streams. Streams will then reflect these effects in their transport of materials to the oceans. The River Continuum Concept (Vannote et al. 1980), a basic component of present stream ecology, views rivers as more than simply downstream transporters. Important nutrient materials moving downstream are retained by physical (e.g. leaves in a log jam) or biological means (e.g., aquatic insects) and held in place where they may be further processed or "spiralled." Under the effects of global warming, input and retention of vital materials in streams will be significantly altered. For example, warmer temperatures will increase rates of bacterial respiration in soil, leading to increased consumption of soil organic material. This, in turn, leaves less material to be leached into streams, and hence lower levels of dissolved organic carbon (DOC) available to stream organisms.

Streamwater nitrogen concentrations are tightly linked to microbial transformations in soils, so alterations of temperature probably will affect the amount of nitrate entering streams. Concentrations of phosphorus are also tightly bound and closely regulated in stream ecosystems. Changes in streamflow will have pronounced effect on the net retention of phosphorus by streams and their transport of this vital nutrient to coastal estuaries.

In many parts of the world, leaf litter input is the chief energy source driving stream ecosystems. Invertebrates shred the leaf material and make the resulting fine particulate organic matter available to the rest of the food chain downstream. Changes in terrestrial vegetation are inevitable in most global warming scenarios. Whether by changing growth patterns or community species composition, these alterations will have an effect on stream ecosystems. As trees die, streams will initially receive an increased loading of woody debris. Primary production of algae might increase due to holes in the canopy shading the stream. Thereafter, nutrient inputs to streams will change as the composition, condition, and timing of leaf litter input changes.

Although stream animals are noted for their resistance to frequent disturbances (like flooding), changes on a larger or more frequent scale, will not necessarily fall within the animals' ability to adapt. Individual animals will have to cope with change over unprecedentedly short times. Life cycles of aquatic insects are strongly affected by temperature cues. Populations of lotic species (those that occur in flowing water) in non-optimal thermal habitats are characterized by low population density and small-bodied individuals. Animals faced with sudden exposure to unusual conditions will have only three choices: to move, adapt, or die. Considerations of genetic makeup and phenotypic variation suggest that *in situ* adaptation is more likely than shifts in geographic range. Extinction of some species remains a possibility.

Some predictions say that global warming will favor increased rates of forest disturbance due to forest fires, convective wind storms, coastal flooding, and hurricanes. Alterations in flow can affect storage and transport of DOC, nitrogen, and phosphorus. Present projections conclude that if floodplains are drier and there is less anaerobic activity, there will be a subsequent decrease in denitrification causing an increased pulse of inorganic nitrogen reaching streams. Whether this increase (and a related phosphorus pulse) will continue, or whether the situation will result in rapid soil depletion with dire effect on streamlife, is still not clear.

Flow regime and vegetation of the flood plain will also have a strong influence on the amount and type of sediment washed into streams. Siltation directly influences habitat available to stream insects and the eggs and fry of fish.

There have been 10 major and more than three dozen minor periods of glaciation in the last million years. Yet scientists at the Climatic Research Unit in England reported that 1988 was the hottest year since records have been kept. They further reported that the six hottest years of the century all occurred in the 1980s. Without additional paleoecological research, little additional help will be derived from the past on what might occur in future aquatic environments. Human activities already have stressed natural systems so severely that it becomes difficult to separate these disturbances by discrete causes. An adequate supply of high quality fresh water is essential to our society. We need to be able to predict the effect of different climate change scenarios to protect what we have, to maintain productivity and diversity, and to develop acceptable alternatives for management.

Freilich recently completed a doctorate in aquatic entomology at U/GA; his research focused on behavior of stoneflies at Grand Teton NP.

Minshall, professor of biology at ID/St/U, is a well-known stream ecologist, and was final summation speaker at the Troubled Waters conference mentioned in this article.

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Arctic Steppe (Continued)

steppe communities may depend on conditions that ensure a high light environment by eliminating the growth of trees, a circumstance likely to occur if conditions become drier. Steppe species might thrive under these conditions because of their aridity tolerance. On the other hand, if conditions become more moist we might expect the distribution of trees to expand, favoring forest understory species. Steppe species might then lose the competitive battle for light as forest encroaches onto south-facing bluffs.

These questions suggest that long-term monitoring of arctic steppe communities, supplemented by basic research, may show them to be useful barometers of global climate change. As interest in that international issue grows, arctic steppe provides a tangible link to our Soviet neighbors and glacial past, a link that may someday result in designation of the Yukon River bluffs as part of an international park.

Wesser is a Biologist at the NPS Alaska Regional Office; Knuckles is a Natural Resource Management Specialist at Yukon-Charley Rivers National Preserve.

In the Next Issue

Because of the additional work involved in preparation of the Global Change insert, the deadline for Park

Science copy was earlier than usual. Many Regional Highlights, the MAB column, and A Sociological Study of Everglades Backcountry by William Stewart, Ray Snow and Mark Ivy will all appear in the Winter issue.

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