PARK SCIENCE

A RESOURCE MANAGEMENT BULLETIN

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PARK SCIENCE

NATIONAL PARK SERVICE

SUMMER 1986

A report to park managers of recent and ongoing research in parks with emphasis on its implications for planning and management

In This Issue

Cover Photo:
Brian Mattos of Pinnacles National Monument ignites a prescribed fire for tung control at Cumberland Island National Seashore. (Story page 3 and following)

Something New Has Been Added

Pollution in the parks – a 24-page insert – is included in the center of this issue of *Park Science*. Put together by Napier Shelton of the NPS Washington Office of Natural Resources, the supplement provides a Systemwide overview of water and air pollution, the widespread degradation of park resources, including scenery, and the legal, scientific, managerial, and communication implications of these pervasive pollution conditions.

The supplement reviews the problems, tells what is being done about them, and perhaps will suggest to at least some readers other ways of meeting and dealing with the issues raised.

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Vegetation Management Course Emphasizes Field Projects

By Susan P. Bratton

For three weeks in April, 1986, 29 park managers from nine regions studied Basic Vegetation Management in a course organized by the NPS/CPSU at the University of Georgia, Athens. The course began in the Great Smokies with lectures on natural and human disturbances, vegetation history, floras and checklists, rare and endangered species and direct human impacts. The class completed field labs on plant collection, monitoring campsite and trail erosion, and evaluating the effects of red spruce decline. Peter White and Kieth Langdon led field trips to Andrews Bald and Cades Cove to investigate historic vegetation management. The visits resulted in vigorous discussion about strategies such as mowing to maintain disturbance dependent rare plant species and fencing to exclude wild hogs from rare plant habitat.

The class then traveled to the University of Georgia for instruction in herbicide use, computer modeling and stress reduction when building roads and trails near native trees and shrubs. A high point of the Georgia sessions was a morning of slide lectures by Darrel Morrison, Dean of the School of Environmental Design. Dean Morrison discussed restoration of native plant communities, particularly prairies, and landscaping with native plants.

The class then moved to Ocmulgee National Monument where they initiated a survey of exotic woody plant species, including kudzu, mimosa, privet and Japanese honeysuckle. In evening discussion, the class evaluated the survey techniques and park needs for exotic plant control, in light of Ocmulgee's role as an archeological site. Traveling on to the coast, the class used boats and canoes to study wetland plant communities in Okefenokee Swamp.

The final week of the course was primarily field labs at Cumberland Island National Seashore. The class sampled grassland vegetation and continued productivity measurements on previously established grazing enclosures in salt marsh. The class then expanded the Seashore's vegetation monitoring system by tagging and sampling twelve 20 x 40 meter plots in live oak forest. For the last three days of the course, the class divided into four teams and tackled current vegetation management problems for the Seashore. One team attempted to remove all the exotic tung trees around Dungeness Historic District, while another team attacked the tung near Stafford Field. The teams not only tested several methods of applying herbicide, including hypo-hatchet, frilling with an ax, stump painting and painting on leaves, but the Stafford team hand grubbed smaller trees with pulaskis and conducted a five acre prescribed burn to test the effectiveness of fire for tung control. The Stafford cost/benefit data indicate that for seedlings and saplings, it is less time consuming and therefore less expensive, to hand pull or dig tung then it is to apply herbicide.

The other two Cumberland teams studied campsite damage and relocation problems. The wilderness team located a potential new campsite near Lake Whitney, while the other team planned a relocation for Stafford Campsite. Both groups established impact monitoring systems and the wilderness team collected soil and vegetation data on an existing backcountry site for comparison with information from the proposed new site.

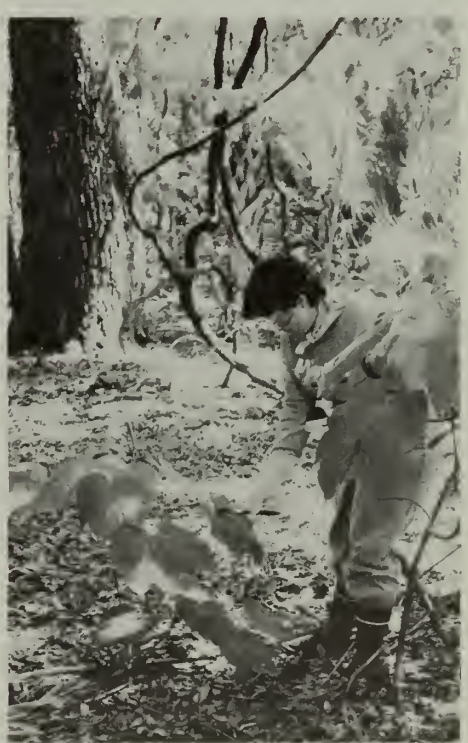
During the course, the class had to complete a series of readings from the professional vegetation management literature, including a number of articles from scientific journals on vegetation management in National Parks. The course ended with a final exam and each Cumberland project team prepared a presentation on its work and submitted a report for the park superintendent.

Staff from the Georgia NPS/CPSU plan to follow up on the tung projects and will use the class's maps and data to construct a final report for the park. The information from the campsite relocation projects will also be directly incorporated in written management recommendations and establishing a base for future monitoring efforts.

Bratton article continues on page 4.

***A cold line** is established during the prescribed burn conducted as part of the tung control project.*

***Using a hypo-hatchet,** Tom Warner of Sequoia/ Kings Canyon NPs injects herbicide into tung trees.*



***Painting herbicide** on tung plants is the job of this student in the vegetation management course.*

Prescribed Fire: Is it an Option for Coastal Barrier Management?

Aside from the very extensive program in Everglades NP, parks in the Southeast Region have done only limited work with prescribed fire. About a decade ago, Great Smoky Mountains NP began a series of research projects in fire ecology and effects, and other southeastern park areas outside of south Florida have since experimented with new directions in fire management. Although one might not expect coastal barrier islands to have both interesting fire histories and fire dependent vegetation, several National Seashores are investigating their needs for prescribed burning.

Over the past four years, the NPS/CPSU at the University of Georgia has studied the sources, size and frequency of past fires in coastal sites; monitored the effects of recent burns; and with the CPSU at North Carolina State, mapped vegetation and fuels. For the four areas investigated, Cape Hatteras, Cape Lookout, Cumberland Island and Canaveral, the probability of a lightning caused fire differs. In the Georgia Sea Islands and south, summer thunderstorms occur almost daily. Canaveral and Merritt Island National Wildlife Refuge have some of the highest frequencies of lightning in the country. Dry lightning is common. The Outer Banks of North Carolina in contrast, have fewer summer thunderstorms, and most natural fires are extinguished by rain. When compiling recent fire history data for Cape Hatteras, Kent Turner, the park resources manager, found only three documented lightning-caused ignitions, two occurring on the same day.

The barrier islands also have differing histories of pre-park, human-caused fire. All the parks had at least occasional fires before European colonists arrived, but the extent and location of Indian burning was probably dependent on the density of Indian settlements, the acreage under cultivation, and the characteristics of the native vegetation. After the colonists arrived, anthropogenic fire continued as an important factor and may have increased in frequency. Kit Davison has found that farmers in the Canaveral area burned their grazing lands to clear shrubs, improve forage, and to reduce the chance of hot fires. Although there is less evidence of residents purposefully setting fires on Cumberland, they did burn fields in the center of the island to improve grazing, and during the "Carnegie era," around the turn of the century, burned the sloughs to keep them open for hunting and canoeing.

Before the Civil War, plantation owners and slaves probably used fire to help clear fields for cotton. Prior to the establishment of Cape Hatteras National Seashore, the residents of the Buxton area burned the woods frequently. Some of these fires probably were intended to clear duck "holes" for hunting. Others may have been intended to clear brush or eliminate snakes. Due to the intense livestock grazing and frequent burning, which reduced fuels, most of these fires were probably of low intensity. Further, nearby grasslands and interior marshes would have burned infrequently due to cattle, ponies and sheep cropping vegetation.

The southeastern parks also vary in the distribution of fire prone plant communities. Canaveral has a high proportion of palmetto or oak scrub lands that build up fuels quickly after a fire. Palmetto can burn again in as little as two or three years. Canaveral's pine forests accumulate deep litter and are also fire prone, although the hardwood hammocks are fire resistent. Cumberland has two major areas of pine-oak-palmetto scrub. Investigation of fire scars around scrub that burned in a controversial lightning ignited fire in 1981 and interviews with local residents suggest this site has burned at least three times this century. The natural fire rotation is thus about 25 years and is probably correlated to coastal drought cycles.

Given time for fuels to accumulate, coastal scrub produces very hot fires that are difficult to suppress within the boundaries of the fire prone vegetation types. Cape Hatteras and Cape Lookout have shrub and grassland communities that will burn, but the fires are generally easier to contain and consume smaller acreages.

A major concern for the manager at Cape Hatteras is the Buxton Woods area. The park owns less than half the woods, the other portion lying outside the legislated boundary. High land prices and the market for summer homes, may expand residential development in mature loblolly pine adjoining park lands. Although the risk of fire here is not exceptionally high, the area has burned before. Buxton Woods would probably only burn under drought conditions or when surface fuel moistures were very low, possibly producing a fire intense enough to threaten private dwellings.

Research into the history of Buxton Woods has found that the site has been logged, grazed and burned since early Colonial times, and these disturbances have changed forest structure. Buxton was probably originally dominated by live oaks, with scattered pine and red cedar. Loblolly pine is now the dominant tree, although young hardwoods are invading the understories of the loblolly stands. Mature pine stands may have twice the surface fuels of mature hardwoods and pine litter is more flammable than oak litter. Dale Wade, of the U.S. Forest Service, has suggested that some of the small hardwood stands in the back dune areas would not burn even during drought.

***Monitoring transects** are established in a bayberry thicket at Cape Hatteras National Seashore prior to prescribed burning. The area is a freshwater wetland that provides habitat for black ducks.*

Considering these differences in fire history and in potential fire management problems, the question then becomes, should the barrier islands utilize prescribed fire, and, if so, where and when? The research data indicate the programs will have to be tailored to the individual parks and may vary in the use of natural versus prescribed fire. Canaveral, for example, has a need to reduce fuels near the boundary, and has already conducted successful controlled burns in palmetto scrub. With appropriate fuel breaks, natural ignitions could be permitted in the wilderness area south of the park boundary.

Cumberland is presently using fire to manage House Field, which was farmed formerly and will remain open to maintain the historic scene near Stafford House. Chief Ranger Kevin Kacer is testing prescribed fire as a potential control for exotic tung trees escaping from old plantations. The park is planning to reduce fuels and establish appropriate fuel breaks around scrub in the Table Point area, and eventually will implement a plan that allows fire in the wilderness.

Cape Hatteras is not presently intending to use fire to reduce fuels in Buxton Woods but will construct a fuel break along the park boundary. The woods should succeed to oak and other hardwoods, eventually reducing the risk of fire even further. Park management is aware, however, that decay of the loblolly stands may cause temporary increases in fuels. Supt. Tom Hartman is initiating work on the unnatural scrub succession along park roadsides and tackling the problem of vista maintenance in areas where modification of drainage or construction of artificial dune lines have encouraged invasion by bayberry.

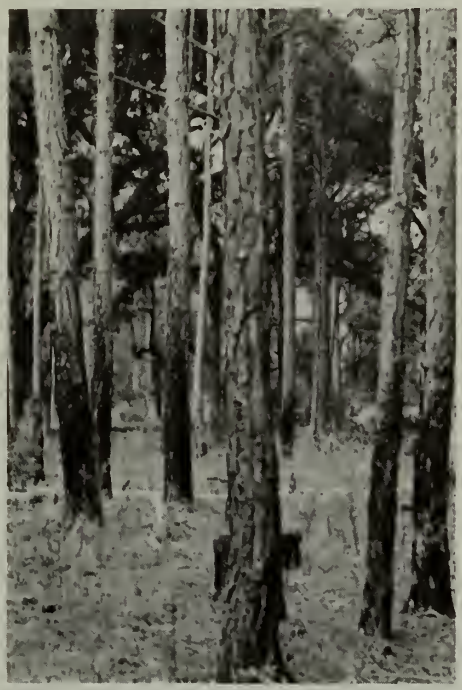
Fire is not a frequent natural disturbance in this type of community, but the shrub thickets are no longer in their natural locations. Fire could be one of the least expensive and least ecologically problematic methods of shrub control. Cape Hatteras hopes to conduct research burns in shrub and interior marsh-edge areas in late winter of 1986 or 1987. Cape Lookout, like Cape Hatteras, has little need to use fire for general fuels reduction, but could consider using fire to reduce shrub invasion particularly near Portsmouth Village.

As the southeastern National Seashores build fire expertise, their management programs will become more sophisticated and should make increasing use of prescribed fire. Managers will have to tailor the programs to individual park needs and natural fire regimes. With the Georgia CPSU now finishing a series of preliminary research projects, research efforts will be integrated into experimental management programs. Future research will include monitoring of permanent plots in burned areas, careful assessment of marsh and shrub zone burning, and construction of forest and scrub stand dynamics computer models to predict effects of long-term managerial changes in fire frequency and intensity.

Reports on the disturbance history of Cumberland Island, Cape Hatteras and Canaveral are currently available from the Georgia CPSU, as are reports on fire and grazing effects on Cumberland Island. Addi-

tional information on Cape Hatteras and Canaveral will be available shortly. The vegetation and fuels maps for Cape Hatteras and Cape Lookout have been digitized and can be obtained by special request to either Hugh Devine at the North Carolina State CPSU at Raleigh (who developed the maps) or to the CPSU at University of Georgia.

Bratton is a Research Scientist and Unit Coordinator at the NPS/Cooperative Park Studies Unit, Institute of Ecology, University of Georgia, Athens, GA 30602.



***Scorch marks on pine** after a surface fire on Cumberland Island National Seashore reach height of about two meters.*

meetings of interest

1986

July 13-20, CONFERENCE ON RESEARCH IN THE NATIONAL PARKS, NPS and George Wright Society co-sponsors, at Col. State U, Fort Collins. Contact Ray Herrmann, 339 Aylesworth Hall NW, CSU, Fort Collins, CO 80523.

Sept. 22-26, THE FIRST CONFERENCE ON PALEONTOLOGICAL RESOURCES IN THE NATIONAL PARK SYSTEM, to be held in Vernal, UT, and hosted by Dinosaur National Monument. Contacts: Dan Chure at Dinosaur NM (801) 789-2115, or Ted Fremd at John Day Fossil Beds National Monument (503) 934-2801.

Oct. 21-24, THIRTEENTH ANNUAL NATURAL AREAS CONFERENCE, at Trout Lodge Conference Center, YMCA of the Ozarks near Potosi, MO. For information write Natural Areas Conference, P.O. Box 180, Jefferson City, MO 65102.

1987

April 6-10, BEAR-PEOPLE CONFLICTS: A Symposium on Management Strategies, at the Explorer Hotel, Yellowknife, Northwest Territories, Canada. Contacts: Paul A. Gray/Peter L. Clarkson, Wildlife Management Division, Dept. of Renewable Resources, Govt. of the NW Territories, Yellowknife, Canada, X1A 2L9. (403) 873-7765.

*See also **Meetings of Interest** in previous issues of **Park Science.***

Grizzly/Wolf Workshop To Be Held in Canada

The 11th Grizzly/Wolf Technical Workshop will be held this year, for the first time, in Canada, according to Brian L. Horejsi, chairperson. Workshop dates are July 23-25, with a field trip scheduled for July 26. The meeting will be held at the primitive Belly River Campground, Waterton Lakes NP, Alberta. With no electricity, no hot water, and no showers, "accommodations" will be what the conferees bring with them . . . tents, campers, etc. Waterton is the sister-park to Glacier NP, and the campground meeting place is five miles north of the Canada-US border.

Contact: Horejsi, Western Wildlife Environments Consulting, Ltd., P.O. Box 3129, Postal Station B, Calgary, Alberta, Canada. T2M 4L7; (403) 264-7781. Registration fee is $7 US or $10 Canadian.

Law Conference Focuses On Ill-Advised Development

The Natural Resources Law Center of the University of Colorado School of Law will present a conference entitled: "Incompatible Development Affecting the National Parks: Preserving the 'Best Idea We Ever Had'" Sept. 14-16, 1986, at the Aspen Lodge, next to Rocky Mountain NP in Estes Park, Colo. Registration is $150, and the Aspen Lodge is offering a reduced room rate for this conference.

The program will focus on (1) the significance of the national parks and the values they represent, (2) several case studies of incompatible development adjacent to a national park which could harm important park values, and (3) alternative proposals for addressing the adverse effects of such development.

Contact: the Natural Resources Law Center, U/CO School of Law, Campus Box 401, Boulder, CO 80309-0401, (303) 492-1286.

***Spanish moss laden scrub,** or poccosin, frame the author, Susan P. Bratton, at Cumberland Island National Seashore. Understory fuels here are similar to western chapparal. Dead snags are products of a lightning ignited fire in 1977.*

NPS Science Meeting Attracts 350 Papers

On the eve of the third Conference on Research in the National Parks, to be held July 13-18, 1986 at Colorado State University, 350 abstracts were being compiled into a volume for distribution at the conference opening.

This year's conference theme is "The Interrelationship of Man and the Environment."

Keynote presentations on current park resource issues will precede the 28 half-day symposia, which will consist of poster presentations followed by round-table discussions. Papers emphasize research results and the application of results to resource management.

According to Ray Herrmann, conference co-chairman, the round-table format will allow in-depth coverage of issues and full opportunity for questions and answers.

Special workshops covering a wide array of resource issues are also being planned in conjunction with the conference.

Science in the Parks

By Rosemary Nichols

Editor's Note: Following is the first of a two-part article based on "A Needs Assessment-Based Review of the National Park Service Science Program in the Rocky Mountain Region," by Dr. Rosemary Nichols and Katherine P. Kitchell of the Utah State University Dept. of Forest Resources. The report was funded by the Utah Agricultural Experiment Station, National Parks and Conservation Assn., USU, and Canyonlands NP. The opening article summarizes the subject from the superintendents' point of view; the Fall issue of Park Science *will deal with the subject as seen by NPS scientists in the RM Region.*

In *Man and Nature in the National Parks,* F. Fraser Darling and Noel D. Eichhorn found "a positive resistance to new (ecological) ideas or to the reacceptance of old in the National Park Service" based upon their personal tour of many units of the system and conversations with agency employees at every level. In their 1967 work they also noted that:

> . . . biological concepts and attitudes have been expressed before, and have received official commendation and approval and still not found their place in existing policy . . . We have had the uncomfortable feeling . . . that such members of the National Park Service as have a high ecological awareness are not taking part in formulation of policy.

Darling and Eichhorn's observations were made less than five years after the establishment of the modern NPS Science program, in 1963. Twenty-one years later the key decision makers in the parks, most of the superintendents, unit managers, and assistant superintendents, profess a positive regard for the use of research in decision making and are calling for more. According to one of them:

> In the early years of the National Park Service it seemed managers didn't perceive a need for research for management or (even for) management: the resource was out there and took care of itself. Now managers are going out and requesting research . . . Research can't answer all questions, but research results can help in reconstructing the historic picture, assessing the environmental impact of actions, and telling us who is visiting and why.

Coupled with much stronger recognition of the utility of research results are concerns about the science program itself. They range from the problem of inadequate funding to the dilemmas of relationship between research and resource management, the control of scientists and the (to managers) politically sensitive information that researchers produce. Overall, the science program was not regarded as "strong" or effective, yet most superintendents reported using what research results they had for making management decisions, for interpretation, and for environmental compliance.

Although clearly a majority view, the positive attitude we found toward the use of research results in decision making was not unanimous. Negative attitudes could be attributed to two problems, lack of small area (particularly historic sites) support, and the "political" problems some research results posed. These two views were perhaps best expressed in the following two comments:

> **In a small historical area, research is hard to come by . . . Disastrous things have been done because decisions were made before research was done.**
>
> **Science is the weak link of the Service. We have only one type of research and that is political. We haven't reached the stage of getting beyond that.**

There was strong agreement among superintendents about the balance between basic and applied research. All responses favored applied, "mission-oriented" research "responsive to management needs." Only one senior superintendent suggested any variation – a ratio of about "70% day-to-day answers and 30% on concerns beyond importance to resource managers at the time."

Next to the generation of management alternatives or providing specific answers to management questions the most common use of research results was for interpretation. Although the use of research in planning was mentioned frequently, superintendents split on whether science could be either generated or utilized in the general management planning process.

Other uses of research mentioned by superintendents included: historic reconstruction, environmental impact assessment, documenting external threats, "telling us who is visiting and why," protecting the resource, managing people, providing baselines, compliance (which was said to follow, and not precede, development), guiding development, addressing legal problems, developing regulations, "building credibility and a constituency for parks," and "buying time," presumably to resolve controversial problems.

Despite respect for what science can do for park managers, there was strong criticism of both past and existing science programs. Of particular concern in regard to the use of research results in decision making was what managers classified as crisis management. However, several superintendents thought reactive management was simply the nature of the beast, an attitude expressed by one who said, "Problems are usually brushfires and you can't wait for research to decide."

Several superintendents admitted that "Managers have ordered scientists to justify a decision." One of the central issues from the superintendents' perspective is who should control the scientist and the release and distribution of his research results, with managers strongly favoring scientists working directly for them. The inverse of the superintendent's concern is of course the problem of the independence of scientists, a critical factor in their pursuit of objective "truth."

When asked "What do you think the strengths of the science program are?" only one-third of superintendents interviewed identified a strength. Conversely, 16 of 18 named one or more weaknesses. Strengths noted included: "the eminently qualified individuals we have access to through the program;" and the University of Wyoming Research Consortium and Cooperative Park Studies Units (CPSUs).

The dissemination of research results, communication generally, small area support, and lack of funding were the most frequently mentioned weaknesses. For these and other problems, strengthening the regional science program was the solution recommended. There was a range of opinion concerning what entity should be responsible for distributing research results. WASO, the special field units (presumably the air and water quality groups at Fort Collins, Colorado), and Region were cited.

Failure to circulate research results apparently occurs at almost all levels. One superintendent noted a lack of communication between researchers; another, lack of interchange between parks. Also mentioned as failed opportunities were information transfer; the presentation of research results in a form understandable to managers; communication between WASO, Region, and the parks; coordination between resource management and research; and communication of research results to the public. Duplication of research was given as another result of communication and information distribution problems.

Lack of a "national clearinghouse" or the summaries provided by the *Annual Report of the Chief Scientist* (not published since 1975), was noted. Several superintendents suggested that more regional or park research symposia would contribute to wider dissemination of research results. *Park Science* was praised as a successful mechanism of communication.

Funding for research was characterized as inadequate, delayed, inflexible, and difficult to obtain for historical research. "Not enough science," unfinished projects, and delayed research results were closely related to funding.

Funding problems and research support generally are most acute in NPS areas perceived as small. Half of the superintendents interviewed felt that they lacked help with: problem identification; development, review, and/or justification of proposals; writing resource management plans; coordination of research; locating expertise, including liaison with universities, and attempting to predict future problems and research needs.

Some criticism was focused upon the organization of the science program. One superintendent contended that "Building programs at the top and forcing them down (to the field level) is a deficiency." Changing emphases in the program correlated with personnel changes in the Washington office were cited several times as contributing to confusion over sources of support, resulting in "taking advantage of windfalls" rather than setting field level priorities.

When asked to identify specific research information needs, seven superintendents noted they had no baseline data or needed a basic resource inventory. Several coupled this with the need for long-term monitoring.

Projects or types of research needed included: the impact of acid rain on both vegetation and cultural resources, endangered species surveys, "soils, geology, water, aquatics," grazed versus non-grazed vegetation patterns, elk population studies, data on past environments crucial to interpretation, water quality (with a concern for heavy metals contamination), and wildlife studies.

Despite a generally positive regard for research results, a number of managers expressed discouragement at the backlog of research needed. An especially pointed comment was:

> **The National Park Service does not have nearly enough information for the job we**

Continued on page 7

Dune Restoration at Fort Matanzas

By Brian Peters

Fort Matanzas National Monument is a coastal park with 100 of its 300 acres located on Anastasia Island, near St. Augustine, Fla. Anastasia, a typical barrier island with shifting inlets and unstable beaches, constitutes a natural system to protect the land and provide an equilibrium between destructive and constructive forces of the coastal environment. At the heart of this protective system is the coastal dune.

Human activities on Anastasia Island have disrupted the long term balance of nature. At Fort Matanzas, vehicle and foot traffic over a number of years has destroyed much of the anchoring vegetation, allowing wind and water to carry away the first two lines of dunes. The park staff decided that action was needed to preserve this natural resource.

The National Park Service owns the southern tip of Anastasia Island except for the intertidal zone, which is in state jurisdiction. From Matanzas Inlet to the north park boundary, the monument contains approximately one mile of ocean beachfront. The inlet is spanned by the Highway A-1-A bridge. In the 1970s the once narrow inlet has widened until high tides threatened the bridge causeway. The dunes in that area had eroded to the line of scrub in the back dunes, creating a danger of extreme high tides cutting away the dune line from the vulnerable south flank. Damaging traffic on the beach also increased, attracted by a substantial sand spit that developed and grew on the west side of the bridge.

Before starting a restoration program a little ground work was required. How much sand was being moved by the wind along the surface of the beach? Could that sand be trapped? At Fort Matanzas, wind direction is variable and unpredictable but the stronger, sand-carrying winds are most often out of the northeast. An experiment using burlap bags and plastic garbage bags was designed to determine how much sand was being moved in the winter months. From November through January the sacks, held open toward the northeast by stakes in the sand, caught an average of one cup of sand every three days. (Information later became available that sand fence will catch approximately 16 cubic feet per linear foot of fence.) This admittedly primitive test indicated that probably enough material was being transported to justify an experimental project.

Many hands make light work. *The vegetation planting work was done by YCC volunteers in cooperation with USDA Soil Conservation Service.*

In December, 1982, a 35 foot section of sand fence was placed a few feet from, and parallel to the base of the dune line, where a steep cliff had developed. The fence was entirely buried by March of 1983. That January, with the help of Scout Explorer Post 414, 500 discarded Christmas trees were staked down at the site.

The success of those winter experiments prompted purchase of over 10,000 feet of sand fence and heavy fence posts. In the fall of 1983 a number of techniques were used and evaluated.

A single line of sand fence, placed at the base of a dune slope, will help to broaden the foundation and sometimes to raise the elevation. Placed two or three feet in front of a "cliff," the single line fence will help slow the slumping of the cliff face, often the most devastating result of storm damage. Any organic material (i.e. grass cuttings, tree limbs, sea weed, etc.) thrown behind the fence will aid in stopping the cliff "slump." The single line of fence also can be used to build a dune by itself, but the dune is not a broad mound and shifts quite easily. The main advantage to this use of sand fence is its economy.

Fence erected in a "zig-zag" pattern is most effective for building a dune line in an open space. The fence catches sand from all directions and builds a broad base. Christmas trees are almost always used with this style because the points at the corners tend to blow out easily without extra reinforcement. The major disadvantage with the zig-zag pattern is the amount of fence required.

East of the Matanzas bridge, the old dunes had completely eroded, leaving a flat plain that could flood in an extreme tide. A perimeter dune was built using the zig-zag pattern, providing a line of protection for the previously exposed flank of the entire dune system. To fill in the flats, large "x" shapes were built of 30 foot fence sections. These x's were slow building but have gathered large mounds of very stable sand and afford prime places for planting vegetation.

Christmas trees collected by the local Boy Scout Council, when used in conjunction with the sand fence, have been very effective in anchoring sand. Many of the trees placed in late December, 1984 were completely covered by February of 1985. In starting a dune from level ground, the Christmas trees are useful as sand collection starters. In some situations they are absolutely essential. Two areas that had been washed out by a late November storm were showing no signs of filling when fence alone was used. Two parallel lines of fence, five feet apart, were then erected and the space between was filled with trees. The whole project was given a head start by using a small endloader and piling 8 inches of sand at the base of the outer fence. Three months later the gullies had filled with 30 inches of sand, bringing them back to the level of the surrounding area.

The fence used at Fort Matanzas is standard snow/sand fence, 4 feet tall with 1½ inch wooden slats, 2½ inch spaces and 13½ gauge wire. The posts are heavy iron fence poles, T-shaped in cross-

Continued on page 8

Continued from page 6

do. In places like Yellowstone there is so much to do there is a 10,000 year backlog. Superintendents have very little baseline information for the decisions we make. We make them hoping they'll be right.

Fifty percent of our managerial interviewees mentioned depending on other government agencies for information needed to deal with park problems.

Fifty percent also questioned the NPS commitment to research. The polarity among responses ranged from "Science is the weak link in the Service," to "Agency commitment is very strong, although it is more so with some people than others." Typical of several "Yes, but . . ." responses was, "As an agency, we have a sound commitment to research, but I question the direction. Sometimes the political pressures outweigh research."

New initiatives that received favorable response were the resource management training program, the training course to enhance managers' appreciation for research, and regional research conferences. Overall, the Service was faulted for poor training and underutilization of its human resources.

Diffusion of initiatives to the field level is apparently slow. Over a year after reorganization of the science program into a decentralized mode, most superintendents regarded the program as "strongly" centralized. New programs were perceived as linked to Washington office personalities rather than field needs and criticized as confusing.

Recommendations received in response to a direct question usually phrased as, "If you had the opportunity, what improvements would you make in the National Park Service's science program?" included: (1) "a roving ecologist for Southern Colorado parks;" (2) giving "a certain percentage of funding from the Wyoming unit to cultural and historical research or establishing a unit like the Wyoming Research Consortium for historical and cultural research;" (3) "establishing a (regional?) committee to help identify research needs, review proposals, and assist with resource management activities;" (4) having "a member of the management evaluation committee which comes to all parks from time-to-time be a resource management person to help identify problems and evaluate the quality of the (resource management program)," and (5) "training to sensitize researcher to manager needs, constraints, and NPS policies, and to sensitize manager to researcher constraints."

Dr. Nichols is a professor in the Utah State University Dept. of Forest Resources.

Dune Restoration

Continued from page7

section. Other organizations in the area have used poles made of other designs, most of which do not hold up to the stresses of the coastal environment. Heavy wire is the easiest material to use in securing the fence to the poles. The wire fence fasteners available through GSA are inexpensive and hold well but are more difficult to manipulate.

A severe northeaster with extremely high tides in November 1984 taught us another lesson . It washed away the first 21 feet along the entire length of the dune line and took with it large sections of sand fence. The sand laden water exerted a tremendous pressure on the fences and pulled down long pieces because they were fastened together. When the fencing was repaired, long contiguous lengths of fence were replaced by separate and shorter (50') segments. In another severe storm tide, only small sections will be lost.

To make the dune system self-sustaining, sea oats (*Uniola paniculata*) were obtained from the USDA Soil Conservation Service and planted by a local 4-H group; 500 plants in April of 1983 and 1984, 1000 plants in April of 1985. Plants on the windward side of the dunes became windblown and died when their roots were exposed. The remainder of the plants were successful, estimated at 90 percent survival. Sand fence protected the plantings and was well worth the cost, since one destructive incident can cancel out many hours of hard work.

Additional dunes are beneficial to the area for their stabilizing effect and additional habitat. There may, however, be undesired results. Extended dunes may occupy what was previously beach, forcing crowded sun seekers into the dune area. This creates trails and begins the destructive cycle again. Sand dunes also can destroy critical habitat for some wildlife species. At Fort Matanzas, black skimmers, Wilson's plovers and least terns (designated by the state of Florida as a threatened species) nest on the shell strewn beaches but plant covered dunes are unsuitable as nesting areas. On the flats previously mentioned, a compromise was reached by building a protective perimeter dune and a few "x" shaped mounds, with ample area left between for nesting. In addition, the sand spit to the west of the bridge is fenced to provide protection to the nesting birds.

Sand fencing alone cannot protect this fragile habitat. Signs once posted along the top of the dune line, reading "Keep Off Dunes," were changed to read "No foot traffic on the dunes" because a large number of beach users thought the signs referred only to vehicles. Enforcement could be difficult but daily foot and vehicle patrols along the beach to maintain high visibility produce results, even on busy days. Citations are rarely used for pedestrian violations since such incidents commonly are followed by sign disappearance or other vandalism. At Fort Matanzas, lower levels of enforcement work well.

Fort Matanzas has a staff of two rangers and two maintenance people. With planning, flexibility, and volunteer help the project is not prohibitively expensive or time intensive. At Matanzas, regular patrols are maintained but the interpretive program has not been diminished; in fact it may have improved, since the rangers have shorter shifts at the Visitor Center and more varied duties.

The most important aspect of this program is that it works!

Peters is Ranger at Fort Matanzas National Monument in Florida.

letters

To the Editor:

Park staff at Sequoia/Kings Canyon NPs (SEKI) recently confronted plans by the Denver Service Center to landscape the forthcoming Clover Creek visitor services development with plant materials acquired from outside the local area. In this particular case, SEKI has already developed the means to collect and grow-out local stocks for in-Park plantings, and intends to insist upon this procedure even if it yields a somewhat less finished-looking landscape.

My concern is that DSC, and NPS in general, appears to have no landscaping policy designed to protect genetic integrity in natural areas, and that park managers throughout the system may not be aware of the damage than can be perpetrated by indiscriminate plantings. I presume from local experience that use of alien plant materials has been standard for NPS landscaping work. Certainly the plantings around our Ash Mountain headquarters include many species not local to the area (e.g. coast live oak, eastern redbud, japanese privet, etc.). A policy to prevent such planting is necessary for educational, ecological and scientific reasons. Let me briefly enumerate and explain these reasons:

I. Introduction of non-native species. Plants of species not local to the target area obviously produce and artificial landscape and mislead park visitors about the nature of local flora. Occasionally, particularly if the introduced species is native to a similar climate elsewhere, the introduction may self-propagate and become a weed, competing with native plants and displacing them. The classic example in these Parks (although preceding national park status) is the introduction of a Mediterranean annual grass flora in our foothills that has almost completely supplanted native grasses and forbs. Around Park Headquarters at Ash Mountain, NPS-introduced broom, pyracantha, toyon, and periwinkle have all become local weeds.

2. Introduction of foreign genotypes of native species. This takes place when native species are supplied by nurseries or other collectors or growers from stock originating outside the local area. Plants with broad geographic or climatic ranges typically show significant genetic variability from place to place (e.g. Clausen, Keck, and Hiesey's classic 1940 study on variability in some California species). Thus plant material supplied from outside the local area is, to some extent, genetically alien. This may simply mean the plants are not adapted to local conditions and fail to thrive or survive. But if they do survive, genetic introgression with local conspecifics is likely. While this may have little long-term ecological significance since natural selection will eventually remove less-fit phenotypes, it does have long-term scientific consequences. Plant population genetics research requires areas in which anthropogenic alterations in the distribution of species and genomes has not taken place, and in which natural ecological and evolutionary processes are relatively uncompromised. Virtually no such areas remain except for large natural-area national parks. Plant geneticists with whom I spoke at the 1982 MAB genetics symposium were emphatic in opposing use of alien genotypes in park plantings.

I can see no good reason why landscaping in national park natural areas should include foreign plant material, except perhaps in the particular case of a native species that has become locally extinct and is re-introduced. On the other hand, the potential mischief in alien introductions is clear. I believe the logic developed here applies equally to animal species, although there may be circumstances in which small, isolated animal populations require artificial introductions of foreign genes from conspecifics to maintain genetic diversity.

David M. Graber
Research Scientist, SEKI

Park Science welcomes comments and/or criticism on the material expressed in all letters to the editor.

superintendent's corner

Some years ago, as operating increases became more difficult to come by, we decided here at Whitman Mission that the easiest, most durable increase possible was from our own improved efficiencies. We designed and implemented a Management System that caused the staff to learn where resources (dollars and manpower) were being used. The system also allowed us to begin to compare one work task against another work task, and evaluate the desirability of continuing unchanged into the future. This was a great eyeopener; we learned more things than we wanted to know.

We used that good information, and made adjustments to more effectively use available resources for the high priority work. We learned that a disproportionate share of grounds maintenance dollars and FTE's were being used to accomplish work in non-visitor use areas . . . also, work that was called for by others (e.g. to abide by county weed control ordinances, and in response to threatened lawsuits caused by our negative impact to our neighbors).

Our desire to be good resource stewards was helped immensely by our inability to afford to continue being bad resource stewards.

Dr. Jim Romo's work (see article on page 9) is the culmination of our desire to save money, be a good neighbor, and provide for the long-term preservation of the park resources. It is also the culmination of outstanding support from the Pacific Northwest Regional Office.

The final step by the park in the study process has been the development of an action matrix spreading the revegetation over a number of years. Some of the recommended herbicide treatments are expensive, as are the specialized seeds. The reduced level of maintenance needs are offsetting only a small part of those up front costs.

This is a pilot project with wide application for the results. Because of the total investment and breadth of application, we have arranged through Bob Dunnagan at Mount Rainier for Resource Management trainee Janet Edwards to develop a simple method to determine if the use of herbicides in the concentration applied are achieving the desired effect. By measuring the effectiveness and success early in the vegetative effort, we think we will be able to make adjustments in following years, further streamlining the program.

As a result of Dr. Romo's advice and counsel, we are actively managing for the desirable grass and saving money in the process.

Robert C. Amdor, *Superintendent*
Whitman Mission National Historic Site

Vegetation Management in National Parks in Arid Areas of the Pacific Northwest

By Jim Romo and William Krueger

A study to refine management of grasslands in arid land parks of the National Park Service's Pacific Northwest Region was conducted by the Department of Rangeland Resources at Oregon State University. The vegetation management plans had to comply with state and local requirements for weed control and limit the need for expensive or labor intensive vegetation management. They also needed to provide environmentally acceptable grassland management alternatives. This study aimed to define methods for suppressing weeds and perpetuating or establishing low maintenance and long-lived vegetation, in line with previously determined landscape management objectives. These objectives also included cost reduction and maintenance of diverse and aesthetically appealing vegetation.

Vegetation management was reviewed and interim vegetation management plans suggested for Fort Spokane in the Coulee Dam NRA, Spalding and East Kamiah Sites of Nez Perce NHP, Craters of the Moon NM, and San Juan Island NHP. A detailed revegetation management plan was prepared for Whitman Mission National Historic Site (NHS).

The Problems in Grassland Management

Much of the native grassland vegetation is degraded in National Parks in the arid environment of the Pacific Northwest Region. The poor ecological condition of these grasslands is primarily a product of land use prior to acquisition by the NPS and post-acquisition vegetation management that did not focus on improving vegetation conditions. Significant disturbance and changes in the composition of grasslands probably began with settlement of the area by pioneers, accompanied by uncontrolled livestock grazing and cultivation of land for crop production. After disturbances, many of these grasslands were left unmanaged; weeds invaded, and soon dominated plant communities. Grasslands later acquired by the NPS were not exempt from continued invasion by exotic weeds.

Introduction of exotic plants into arid grasslands in the Pacific Northwest has altered plant succession. Many exotic plants are weedy, representing the gamut of low to high successional roles. Several introduced species preempt native species successionally, and once they establish and dominate a site, native species are very slow to reestablish. If these weeds are not controlled, natural reestablishment of native species undoubtedly will take centuries. In many areas artificial reseeding is requisite for reestablishing grassland communities that resemble predisturbance composition. Where native vegetation is severely depleted the natural seed source often is insufficient to insure recruitment of new plants into the populations and the probability of their widespread reestablishment is low.

Compounding the problem is mortality of established plants. Therefore, a rare sequence of years with high seed production and favorable conditions is needed for establishment of native seedlings. Because of harsh environmental conditions, competitive weeds, and few remaining native plants, reproduction of native plants is extremely slow and communities remain dominated by introduced plants.

Exotic plants may be better adapted to the sites than native species because either they are competitively superior to native species or they occupy niches that were previously occupied by native species. Most exotic species are prolific reproducers whose seeds germinate and seedlings grow over a wider range of temperature and moisture conditions than many indigenous perennials. These characteristics allow exotic species to occupy more space and use resources, particularly soil moisture, in advance of developing perennial seedlings. Because of these characteristics natural regeneration of indigenous perennials usually is low unless exotic species are controlled. If seed production of weeds is reduced prior to seeding perennial species, and weed populations are suppressed during the first year or two after seeding, indigenous perennials usually can establish from seed. Once established, native perennials thrive and successfully outcompete exotic species.

Suppression of weeds is dependent on reducing niches and resources through maximizing growth and reproduction of desired perennial species. Controlling one weed species without establishing or encouraging the growth of desirable perennial plants usually results in replacement of the one weed with another that can tolerate the control treatment. Exotic plants have been best adapted to the disturbances in these grasslands and it is probable that if desired perennial species are not established and properly managed, weedy species will dominate in the future. Exotic plants will remain a permanent component of the flora in these grasslands and it is likely that new weeds will be introduced.

Managers have at least two alternatives: 1) control weeds as they appear in the grasslands, or; 2) limit invasion of new weeds by managing for desired plant composition while simultaneously controlling existing weeds.

Weed control can take three forms: direct control, indirect control, and the combined effects of direct and indirect control. Direct control entails implementing techniques or technology, such as herbicides, for controlling a particular weed species. Direct control alone usually is ineffective, providing short-term reductions in weed populations. With indirect control a predetermined desired vegetation is the target for management; competitive advantage is given to the desired vegetation by manipulations such as prescribed burning, mowing, or grazing. Indirect control gives the most effective long-term control of weeds. The combined effects of direct and indirect control require implementation of both strategies. Weed control in National Parks of the Pacific Northwest Region has traditionally relied on direct control, but emphasis now is being placed on direct-indirect control with indirect control of weeds being the long-term management objective.

Whitman Mission National Historic Site: A Case Study

Whitman Mission NHS (WMNHS) lies in the Palouse Prairie of southeastern Washington. After nearly 150 years of grazing, indiscriminate use of fire, cultivation of land for vegetable and grain production, and introduction of exotic plants, very little of the vegetation in the park resembles its presettlement structure and composition. Most disturbance occurred before these lands were acquired and incorporated into WMNHS. Thus, deterioration of vegetation is not recent, but is a product of past events. Although invasion of weeds may appear to be a recent phenomenon, what is actually occurring is an influx and succession to more conspicuous and better adapted exotic plants.

***On some sites** the density of native species has been reduced by disturbance; their density will be increased by seeding and planting containerized seedlings.*

The most common exotic weeds at WMNHS are diffuse knapweed *(Centaurea diffusa)*, yellow starthistle *(Centaurea solstitialis)*, teasel *(Dipsacus sylvestris)*, poison hemlock *(Conium maculatum)*, Canada thistle *(Cirsium arvense)*, and cheatgrass brome *(Bromus tectorum)*. Prior to settlement the native bunchgrasses, basin wildrye *(Elymus cinereus)* and bluebunch wheatgrass *(Agropyron spicatum)*, probably dominated lower terraces and higher terraces and benches, respectively.

The present composition of plant communities is related to the frequency and severity of disturbance, time elapsed since disturbance, soils, topography, available sources of seeds, and past management. Before implementation of the revegetation management plan, weeds formed monocultures in some areas; in other areas nearly all the above weeds were present. In areas that supported a mix of exotic species, multiple control methods were required because of the weeds' variety of growth strategies and the ineffectiveness of a single treatment. Weed control treatments, applied alone or in combination, include prescribed fire, mechanical manipulations, grazing, and in some cases herbicides.

Within the 100 acres at WMNHS, 15 revegetation units were superimposed on the five landscape management units established in the Landscape Study and Management Alternatives for WMNHS. Delineation of revegetation management units was based on topography, soils, existing vegetation, potential native vegetation the site can support, and the ease of applying weed control and revegetation techniques.

In developing the grassland management plan for WMNHS, vegetation management was switched

Continued on page 10

Vegetation Management

Continued from page 9

from a system of direct weed control to a plan that favors growth of desired vegetation. Initially these changes in management will require direct-indirect control methods, but eventually only indirect control of weeds will be needed.

In some places no native species exist; in others a few native plants have survived. Where native plants are absent, existing vegetation will be eliminated and native species reestablished by seeding. In areas where some native vegetation exists, the density of indigenous species will be increased by seeding and planting containerized transplants. "Magnar" basin wildrye and "Secar" bluebunch wheatgrass, improved varieties of the indigenous grasses, will be used for reseeding. Irrigation may be used to insure establishment; however, when established these species will not require inputs such as irrigation and fertilizer.

As native vegetation is reestablished in the Park, management will be implemented to perpetuate it and suppress weeds. Long term plans call for use of prescribed fire and a systematic livestock grazing system. Approximately one-third of the Park is leased and grazed under the NPS Historic Property Leasing Program, but this may be increased to approximately one-half of the area.

Weed control and revegetation efforts will be monitored. Permanent plots will be established and evaluated at regular intervals. Information derived from monitoring will be used for evaluating the effectiveness of treatments and in formulating vegetation management in other National Parks in the Pacific Northwest Region.

Summary

The grasslands in National Parks in arid environments of the Pacific Northwest Region are altered from their potential composition, structure, and function. Because these ecosystems are highly modified, they are open to invasion by many competitive and undesirable plants. Exotic plants are a permanent part of the flora of these grasslands and management must be designed to minimize their success while maximizing development of desired species. Current problems faced in vegetation management are the product of past management, necessitating that new and innovative management prescriptions be developed to perpetuate the desired vegetation.

Effective management of these grasslands requires adjustments in vegetation management philosophy. Grasslands must be managed to minimize dilemmas rather than to treat vegetation problems as they develop. Cause-effect relationships must be scrutinized and management designed to treat the causes of problems rather than the effects. Management cannot stop with control of weeds and reestablishment of desired perennial vegetation; it must be sustained to perpetuate desired vegetation.

Romo was a research associate and Krueger is Department Head of Rangelands Resources at Oregon State University. Romo is now an assistant professor of Plant Ecology and Range Management at the University of Saskatchewan, Canada.

Splendid CUE Rises From Soggy Teahouse Dregs

By William Anderson and Dick Hammerschlag

It all came together on January 20, 1985, a day so cold that the outdoor activities of Inauguration Day had to be cancelled. All systems at the Ecological Services Laboratory had failed under this cold weather stress; and, though the facilities at the new location were not completely renovated, there was little choice but to move. With encouragement and support of Jack Fish, Regional Director, the natural science program of the National Capital Region (NCR) began moving to their new home. From many suggestions, Mr. Fish selected the Center for Urban Ecology (CUE) as the new name for the laboratory-office area since he feels that name best describes the types of services the NCR natural science program provides.

From a scattered science group, operating out of the Hains Point "Teahouse" (too often underwater from a swollen Potomac River), the NCR headquarters building on Ohio Drive, and a trailer in Prince William Forest Park, the NCR natural science program has been transformed into a compact, efficient organization housed at what used to be the Palisades maintenance yard of Rock Creek Park. The now unified crew, still led by Regional Chief Scientist, Dr. William Anderson, consists of 11 permanent members in a well-designed facility that has laboratories for soils and agronomy, water quality and related aquatic problems, integrated pest management (IPM) and plant pathology, plant ecology, and wildlife.

The new complex displays ingenious adaptive use of vehicle bays to accommodate laboratories and offices. A passive solar walkway has been constructed outside of what had been the bays. This provides protected connection among all the offices and laboratories without invading them. When the vehicle doors were removed, a wall separated the bays from the solar walkway. Internally the bays were renovated so that two offices were made from a single bay, or two bays were made into one laboratory.

On a recent tour of the CUE, Dr. Richard Hammerschlag, Chief of the CUE brimmed with satisfaction. "One of the great advantages we have now," he said, "is the ability to isolate laboratory functions and separate them from office-type duties. Cross contamination from soils samples to water samples and plant pest material is relatively easily contained." Included in the CUE are a transfer room where microorganisms can be isolated and maintained in pure culture; a utility area for preparing media, distilling water and cleaning glassware; an environmental control room with growth chambers that can be programmed to mimic growth conditions for organisms under study; a small conference room; and a small, but complete kitchen facility.

The new facility is conducive to constant interaction among the scientists and technicians of the CUE, yet it provides them privacy and isolation necessary to accomplish more involved and complex tasks. NCR Chief Scientist Anderson is an ardent advocate of the need for research on problems associated with natural resources in urban parks. "Vegetation, soils, water, air and wildlife are significant components of our urban National Parks," he said. "These are natural resources, and we must understand the needs and limitations of these resources in order to manage these parks well. The taxpayers and elected officials may not get to the great natural parks too often, but the parks of our nation's capital are the setting for some of the most heavily visited sites in the entire National Park System. What is done in managing resources here in the Washington, D.C., area reflects not only on NCR but on the resource stewardship of the entire Service. Our work speaks the language city people understand, and we are an urban nation."

In addition to managing the laboratory, Dr. Hammerschlag is working with the impact of water quality parameters on submersed aquatic vegetation, with emphasis on the exotic species *Hydrilla verticillata*. "All this is in connection with the dramatic rebirth of the Potomac estuary," Hammerschlag said. "In the past three years we've really begun to see improvement of water quality in the Potomac resulting from improved treatment of waste water and better run-off control through the watershed. The Potomac received a little help from conscientious watershed management and now it is further correcting itself."

Dr. Jim Sherald is engaged in an ambitious pest management program. His major research emphasis is on fastidious xylem-inhabiting bacteria which are associated with biotic scorch of such major shade tree species as the American elm and the sycamore. Sherald also is responsible for Dutch elm disease management and research, and coordinating the Regional integrated pest management program. He cooperates extensively with the U.S. Forest Service in research, monitoring and mitigation of gypsy moth. Pest management assistant, Carol DiSalvo, provides Jim invaluable aid in maintaining the pest management activities.

Kudzu, English ivy and wisteria are just three of the exotic species targeted by Dr. L. Kay Thomas and his plant ecology research team. The team is exploring approaches that will reduce the impact or eliminate exotic species in such a way as to *release* the native vegetation to its former dominance. A vast array of tactics is being evaluated – 16 tactics for kudzu alone, including grubbing out, grazing, and prescribed burning in an urban setting. "All of these tactics are being looked at from an ecological perspective – how least to interfere with the re-establishment of native plants," said Thomas.

Dr. John Hadidian, the CUE urban wildlife specialist, is now working primarily on raccoons and the rabies among them that has become a new problem for urban park managers. The study on raccoon ecology in Rock Creek Park and its urban environs includes the animals' food preferences, denning areas, territories and movement patterns. Hadidian also has worked on the biological bases for implementing a plan to mitigate the impact of a dense population of squirrels on the vegetation in an urban National Park.

Jim Patterson and John Short, research agronomist and soil scientist respectively, are broadly

A passive solar walkway *connects all offices and laboratories with the administrative area, conference room and common use area of the Center for Urban Ecology. The brick columns define the former vehicle bays. This modification of the former Palisades maintenance yard allows total utilization of existing space for laboratory and office purposes, rather than sacrificing any to interior passageways.*

One of the 5 similar laboratories *in the Center for Urban Ecology. Each laboratory occupies two former vehicle bays.*

Two offices, similar to this, *were created from a single vehicle bay. Acoustical wall paneling and carpeting on the floor minimize sounds. A keyboard and video display in each office is hard-wired to the computer operating system in the administrative area.*

involved with the description and characterization of man-influenced soils – how to modify them and make them more productive for urban landscapes. Their work covers turf evaluation and the formation of crust when soils are compacted. "We study how such compaction affects air and water movement in the root zone," Patterson said, "and look for ways to offset heavy user impacts on this resource so critical to urban parks."

A 16 port computer system has been installed to coordinate and unify the functions of the CUE. All the offices are tied into the computer system, which is complete with graphics capabilities, word processing, data base management and statistical packages. Each office has a keyboard that is hard-wired into the central processing unit thus avoiding expense and duplication while allowing each person to work at his own desk and have the advantage of an increased central storage capacity. Julie Riedel administers and maintains the computer system, and assists the CUE staff and park personnel on data management issues.

Also housed in the facility are the offices and warehouse of the Parks and History Association. The Association is a cooperating association that operates park-related publications outlets at most major National Park Service sites in the National Capital Region.

The Division of Natural Science Services operates a five-acre greenhouse and nursery complex on Daingerfield Island along the George Washington Memorial Parkway just south of Washington's National Airport. In addition to being an integral part of the research activities of the CUE, the greenhouse and nursery provides special plant material to the parks. Much of the material made available by the nursery has resulted from the CUE research effort or is native plant material that is not available through commercial sources.

Pollutants Found In Rainier, Olympic

Prompted by evidence of acid rain and arsenic contamination in the North Cascades in the late 1970s and 1980s, Oregon State University research has found areas in both Olympic and Mount Rainier NPs where contamination in vegetation is substantially higher than background levels. Mount Rainier, with more exposure to pollution from the Seattle-Tacoma industrial areas, was found to be more contaminated, but the extent of pollution in Olympic NP surprised the scientists.

The research does not suggest levels that are an obvious threat to plants or animals in any short-term sense, according to Research Biologist Ed Starkey of the OSU/CPSU, "but in the past Olympic NP has been used as a 'clean' basis for comparison to other, more polluted areas . . . If Olympic is not quite as clean as we thought, then the other areas may be more contaminated than past research has indicated."

Now that background levels of certain pollutants have been established for these parks, Starkey said, any increasing pollution can be monitored with greater accuracy.

First National Social Science Symposium Held

More than 250 registrants gathered at the Oregon State University conference center on May 12 to hear William R. Burch of Yale University School of Forestry and Environmental Studies sound the keynote of the First National Symposium on Social Science in Resource Management. The week-long session was sponsored jointly by OSU, the National Park Service, the U.S. Forest Service, and a half dozen allied organizations.

Burch challenged the assemblage to develop theoretical interpretations of the monumental body of social science data already existing – interpretations from which social scientists can arrive at generalities that will generate quick answers to specific problems.

"We have a rich, full set of solid empirical data already," he told the conferees. "Too often we tend to 'do another study' when we should be looking instead to the work already done. I submit that we *can*, right now, from the knowledge we already possess, aid in resolving specific management problems."

Burch named Frederick Law Olmsted, John Wesley Powell, and Charles Darwin as three great progenitors of today's applied, resource social science. Olmsted, he said, saw the operational balance of nature with man as a design problem. Powell's genius lay in his understanding that in the arid West it was water, not land, that was the prime resource so far as people were concerned. Therefore the arid West would require different social institutions than the humid East if resources were to be sustainable.

"And Darwin," he said, "demonstrated for all time the importance of the narrative form as our species tries to understand its place in the cosmos. This young man's voyage was more than a journey – it was a vision." Burch cited Darwin's observation that no one could contemplate "undefaced nature" without feeling that "there is more to man than the mere breath in his body."

Burch used the Symposium abstracts (180 of them) to describe "where we are now" as a discipline. We are continuing to reinvent nature, he said, but the conference papers form a mosaic that offers hope for the future of the social sciences. He described them as covering four major areas – the recreation system, the patterns of communities and institutions ("too often skewed in favor of stability and no-change"), political economy, and positive contributions to resource policy, planning and management.

The raw materials of the Symposium, Burch suggested, "are broadly representative of the base from which social scientists can draw some important general conclusions. And as we extract these conclusions and form a body of knowledge that will support *predictive probabilities,"* he said, "our work as social scientists will achieve recognition as worthy of integration into the operational decision making process.

"The human species is the only one we know of that has the capacity to wonder and to dream about life's meaning," Burch concluded. "Science itself is but another set of stories to contain and to celebrate the mystery and wonder of life."

The profession – the discipline – that takes man and his dreaming capabilities into the natural resource management equation is one whose work, Burch implied, will never be finished.

Instead of a Symposium Proceedings, several edited volumes will be produced. Prospective authors have been invited to submit their manuscripts for publication consideration. Editors will formulate their volumes and review the materials submitted during the summer and authors will be notified by September of the review decisions. Seven volumes currently underway are: Book I: Rural Communities, Forestry and Parks; II, Social Behavior and Natural Resources; III, Leisure Behavior in Parks and Forests; IV, Applied Science in Resource Management; V, Economics and Non-market Valuation; VI, Social Science and Natural History Interpretation, and VII, Human Dimensions in Wildlife.

Donald R. Field, conference co-chairman and series editor, indicated that an additional two volumes are under consideration. Field may be contacted at the OSU Department of Resource Recreation Management, College of Forestry, Corvallis, OR 97331.

mab notes

The U.S. Biosphere Reserve program is in high gear. In April two new reserves were approved by the Paris MAB Bureau: the Carolinian-South Atlantic BR, a multi-site reserve that includes Cumberland Island NS and Cape Lookout NS, as well as a variety of other areas under Federal, State, and private administration; and the Glacier Bay-Admiralty Island BR. The Bureau also approved expansion of the Mojave and Colorado Deserts BR to include part of the San Bernardino National Forest. A U.S. MAB selection panel has produced a draft report on a proposed Chesapeake Bay BR that would include estuarine portions of five rivers and two special interest areas. Each river has important research sites or stations and a core area that is protected. The entire Chesapeake Bay estuarine system would be a "zone of cooperation."

Several site managers' workshops have been convened or are planned, to discuss establishment or expansion of biosphere reserves. In December 1985 a workshop discussed linkage of Great Smoky Mountains and Coweeta BR's to form a Southern Appalachian BR, and the addition of Oak Ridge National Laboratory and several State and Forest Service areas. Tommy Gilbert, former NPS MAB Coordinator, has developed a detailed plan for this biosphere reserve as the center of a regional demonstration project on environmental research and management. A workshop was held in March to discuss formation of a Cumberland Plateau BR that would include Big South Fork NRA and several non-NPS areas. Another was held in May on a proposed Central Appalachian BR comprising Shenandoah NP and parts of two national forests. This summer other workshops are scheduled for site managers to discuss formation of biosphere reserves recommended by a selection panel for the Lake Forest Province. The only NPS areas included are Isle Royale and Voyageurs, as parts of a 4-unit reserve along the Minnesota-Ontario border.

MAB selection panels have a biogeographic classification of U.S. coastal areas for use in identifying potential biosphere reserves, but refined methodologies for making such selections are needed. A pilot project headed by G. Carleton Ray of the University of Virginia is being planned to develop a MAB classification of representative ecological areas in the Caribbean or another regional sea as a model for similar projects elsewhere. The principal products of the study will be a geographic information system, strategic assessment, classification of the study region, and recommendations for MAB guidelines and criteria for selecting biosphere reserves in dynamic coastal/marine areas.

The MAB inventory of U.S. reserves 5000 acres or larger is classifying all such protected areas, public and private, according to management objectives and ecological communities. The project will make this information available both graphically and in backup files, will identify deficiencies in the U.S. protected area system, and will provide an information base for use in planning, management, and impact assessments. This summer the inventory methodology will be tested using the whole state of Florida, where natural diversity is high, development pressures are a threat to ecosystems, and information on protected areas is good. The revised methodology will then be applied to other regions of the U.S. as funding becomes available.

A workshop on coastal protected areas in the Lesser Antilles was held July 8-12 in the U.S. Virgin Islands. The objective was to discuss selection, establishment, and management of coastal protected areas, and to use practical experience in the region to draw lessons for the future. The Virgin Islands BR was the focus for part of the workshop as well as an important case study.

Bill Gregg, WASO, and Bob Stottlemyer, NPS/CPSU, Michigan Technological University, attended the European MAB Conference on Biosphere Reserves and Ecological Monitoring, March 24-28, in Czechoslovakia. The principal purpose of the conference was to report activities and identify opportunities for carrying out the MAB Action Plan for Biosphere Reserves in Europe. During and after the conference, several possibilities for U.S. cooperation were explored, including NPS fire management and other expertise, and woodland caribou reintroduction, with Finland; resumption of bilateral ecological monitoring in biosphere reserves, with the Soviet Union; and long-term integrated ecological research on small watersheds, with the Federal Republic of Germany and Czechoslovakia.

Bill Gregg and Peter White attended a meeting at Oak Ridge National Laboratory on April 10 that further explored opportunities for collaboration between the US and the Federal Republic of Germany in long-term ecological research, monitoring, and specimen banking. US and FRG representatives agreed to share expertise in setting up a program of these activities in West Germany. American experience with integrated watershed research should be especially valuable. In the other direction, a West German specimen banking program to provide early warning of persistent changes in ecosystems associated with chemical pollutants, should benefit the US, which lacks such a program. Cooperation between specific biosphere reserves in each country also was recommended.

Peter White of the NPS/CPSU, University of Tennessee, attended a symposium on temperate forest ecosystems held at China's Changbai BR, July 5-11. Opportunities to develop cooperative activities in ecologically similar temperate forest biosphere reserves, and building a system of protected areas in China were principal items on the agenda.

Napier Shelton
Technical Publications Writer-Editor WASO

POLLUTION IN PARKS

Natural Resources Programs
National Park Service

POLLUTION IN PARKS

JUNE, 1986

A report on National Park Service activities to maintain environmental quality in the National Park System

Contents

Editor: Napier Shelton

Cover: Larry Morrison

About This Report

Air and water pollution are among the most serious, widespread, and complex problems facing our national parks, even the most remote. Air pollution, from sources near and far, has been detected in virtually every park unit, natural or cultural, where monitors have been placed. In many areas it has caused degradation of scenic views or injury to vegetation. Water pollution due to activities within or upstream from parks is an actual or potential concern in more than 160 units of the System. To address these problems we are using a myriad of available tools: legal, scientific, administrative, managerial, and communicative. Many units and individuals in the National Park Service are involved.

This report, *Pollution in Parks*, has been prepared by the Office of Natural Resources to provide an overview of the problems and what is being done about them, an update on current activities, and sources of further information. We hope such a review will be useful to everyone concerned with environmental quality in our national parks.

My sincere thanks go to all those individuals who contributed to this report.

Richard Briceland
Associate Director, Natural Resources

THE NATIONAL PARK SERVICE AND ENVIRONMENTAL QUALITY—AN OVERVIEW

An ozone-injured Jeffrey pine in Sequoia/Kings Canyon NPs contrasts with a healthy, ozone-tolerant specimen in the background.

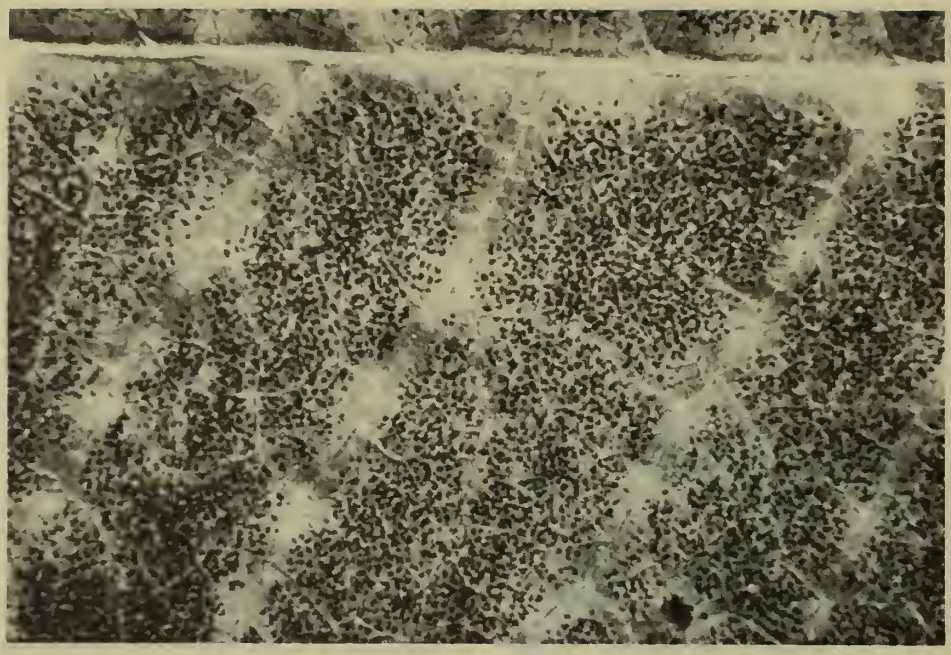
The following preamble to this report briefly describes the ways the National Park Service addresses pollution problems. Subsequent sections discuss current regulations, research activities, situations at specific parks, and other information of interest to those involved with environmental quality in the National Park System.

A Bit of History

Pollution, as might be expected, became a major concern in the natural national parks later than in more developed parts of the country. Chicago passed a smoke ordinance as early as 1881, to be followed by other large cities in the next few decades. The first serious Los Angeles "smog" to attract public attention occurred in 1943. In the mid-1950s, acidic (low pH) precipitation was reported in the northeastern U.S. Environmental concern grew enormously during the 1960s, perhaps stirred most strongly by Rachel Carson's indictment of pesticides in *Silent Spring*, published in 1962. Burning chemicals on the surface of the Cuyahoga River, and a "dying" Lake Erie symbolized the seriousness of water pollution.

Among major governmental responses to these problems were the Clean Air Act of 1963 (particularly as amended in 1970 and 1977), the National Environmental Policy Act of 1969, creation of the Environmental Protection Agency in 1970, and the Water Pollution Control Act of 1972. Yet at the beginning of the 1970s, pollution still did not rank high as a worry for park managers. In William Everhart's book, *The National Park Service*, published in 1972, the only reference to such problems was mention of agricultural pesticides in water flowing into the Everglades. Instead, attention was focused mainly on handling the pressure of rising visitation.

But this situation changed dramatically during the ensuing years. The 1969 annual report of the Office of Natural Science Studies listed only four studies of pollution in the park system (three on pesticides, one on water quality). The (unpublished) report for 1977, by contrast, listed 48 (28 on water quality, 14 on air quality, 3 on pesticides, and 3 on radiation). This Systemwide annual report was discontinued the following year, but some regions produce such a listing. In 1984, in just three of the ten regions—Mid-Atlantic, Midwest, and Pacific Northwest—a total of 93 projects dealing with environmental quality were listed (64 on air quality, 26 on water quality, 1 on pesticides, 1 on "ecotoxicity," and 1 on toxic waste). Among the ten threatened resources reported most frequently in *State of the Parks, 1980*, air quality ranked second (140 parks) and fresh water quality ranked fifth (130 parks). Air pollution injury to vegetation, acidification of lakes and streams from acid precipitation, and visibility impairment have become widespread concerns in the national parks.



Black spots on this close-up of a common milkweed leaf indicate ozone injury. Milkweed plots have been established in many national parks to monitor ozone effects.

Waste from outside sources poses a threat to surface and ground water quality in many park units. Deterioration of cultural resources from exposure to air pollution is a long-standing, but only recently publicized, problem in many urban parks and even some rural areas.

Organizational Responsibilities

The National Park Service deals with pollution at the national, regional, and park levels. The principal national offices involved are the Air Quality Division, the Water Resources Division, the Preservation Assistance Division (Cultural Resources), and the Engineering and Safety Services Division (Maintenance). At the regional level, air quality and water resources coordinators provide liaison between the national offices and field units. Regional Chief Scientists administer some of the monitoring of air and water quality conducted in specific parks. A few parks, such as Great Smoky Mountains, Sequoia-Kings Canyon, and Olympic, have staff scientists engaged in research on environmental quality, but most such research is conducted through contracts, by Air Quality and Water Resources personnel, or by institutions not funded by NPS. Park staff members carry out most of the ongoing meteorological and pollutant monitoring.

Mitigating pollution problems that arise within parks is primarily the responsibility of park managers and maintenance staffs, with assistance from the regional or national office if necessary. Addressing problems that originate outside parks often requires cooperation among all levels of the Park Service and relevant Federal, State, and local agencies.

Air Quality Division

An Air and Water Quality Division was created in the Washington office in 1978 and later was split into two divisions. The Air Quality Division has a professional staff of eighteen people, most of whom are in Denver, with small units in Fort Collins, Colorado, and Washington, D.C. It administers four major technical programs:

1) The Division has been monitoring air quality and visibility in units of the National Park System since 1978. The present monitoring program involves sulfur dioxide monitors at 11 parks, ozone monitors at 19 parks, total suspended particulate monitors at 16 parks, nitrogen dioxide monitors at two parks, a hydrogen sulfide monitor at one park, fine particulate monitors for visibility at 30 parks, teleradiometers for visibility at 29 parks, and cameras for visibility at 36 parks. In FY 1986, air quality monitoring, including visibility, fine particulate matter, gaseous pollutants, and meteorological monitoring, will be initiated in nine additional parks.

2) In 1982, the Air Quality Division launched a major Biological Effects Program to study the effects of air pollution on vegetation. The program includes air pollution effects surveys, sensitivity screenings, trace element surveys, and ecological surveys, with activities in FY 86 in over 60 parks. Pollutant fumigation studies have also been performed to determine levels at which various species are sensitive to air pollutants. Injury to vegetation, especially from ozone and sulfur dioxide, has been documented in almost 40 parks. Lichens, which are especially sensitive to air pollution, have completely disappeared from parts of some parks. Fumigation studies on quaking aspen genotypes from polluted and non-polluted regions indicate that sensitive genotypes in the more polluted regions are disappearing.

3) Since 1979, the Division has been reviewing permit applications for proposed new facilities that might affect class I parks, which, under the Clean Air Act definition, includes most national parks over 6,000 acres in size and most wilderness areas over 5000 acres, except for the new areas in Alaska. The state in which the proposed project would be located makes the final decision on the permit application, which may be denied if the NPS demonstrates that an adverse impact on park resources would occur. The Division has reviewed permit applications for more than 100 proposed projects. Under a Memorandum of Understanding (MOU) with the Fish and Wildlife Service (FWS), the Division also reviews permit applications affecting FWS areas. To date, 34 applications have been reviewed under this MOU.

4) Also since 1979, the Air Quality Division has been applying and developing various mathematical models for tracing and predicting the movement and concentration levels of air pollution. Because sulfates are especially important contributors to visibility impairment, and are an important component of acid deposition, the Division has developed both diagnostic and prognostic long-range transport models to estimate sulfur dioxide and sulfate concentrations. To date the models have been successfully applied to much of the eastern United States, including Shenandoah, Acadia, Great Smoky Mountains, and Mammoth Cave national parks. Because of the observed effects of ozone on natural vegetation, similar model development is underway to identify source regions that contribute to ozone levels in park units.

The Division also integrates air resources management into Service operations and planning, develops interpretive materials for park use, and participates with Federal, State, and local agencies in developing regulatory programs.

Water Resources Division

The Water Resources Division, with 21 professionals, many of whom deal with water quality, has three units in Fort Collins, Colorado, one in Denver, and one staff member in Washington, D.C. Of the five principal issues the Division deals with, two involve water quality: identification and mitigation of external and internal influences on park water quality and quantity; and location of potable water supplies.

About half of the Division's projects are concerned entirely or partly with water quality. Much of the work is assessing water quality or setting up long-term

monitoring programs. Water quality is a constant concern in the park system, especially as it is affected by external influences. Inadequate waste water treatment by municipalities and industrial plants, acid mine drainage, and toxic waste are some of the major causes of water pollution in parks. A large study of irrigation drainage, sparked by selenium damage in a national wildlife refuge in California, has been launched by the Department of the Interior. Such toxic drainage may be affecting units of the National Park System as well.

Acid Deposition Research

NPS research on acidic deposition is administered by the Office of Natural Resources and the Preservation Assistance Division in Washington, D.C. It is conducted as part of the National Acid Precipitation Assessment Program (NAPAP), a 10-year, federally sponsored program to study causes and effects of acid deposition and to recommend actions to be taken. The NPS is one of 12 Federal agencies and four National Laboratories in the program. National Park Service personnel at the national, regional, and park levels are involved. Park Service work has focused on deposition monitoring and integrated watershed studies. The Service, in cooperation with the U.S. Geological Survey, Bureau of Land Management, National Oceanic and Atmospheric Administration, and state agencies, is conducting long-term monitoring of the chemistry of wet atmospheric deposition at 32 park sites, part of the 150 sites currently in the National Atmospheric Deposition Program/National Trends Network. Integrated watershed research is underway in five parks—Isle Royale, Rocky Mountain, Sequoia-Kings Canyon, Olympic, and Shenandoah—to learn how atmospheric deposition affects ecosystems.

Effects of acidic deposition on cultural resources of the National Park System are being investigated, also under NAPAP, by the Preservation Assistance Division in Washington. Deterioration of historic materials, particularly marble, limestone, and statuary bronze, is being studied through laboratory research, *in situ* monitoring of cultural resources in parks, and controlled field exposures at several sites selected to represent the range of potentially impacted environments.

Ray Herrmann of the Water Resources Division summarized the situation as follows: "In reference to parks, we can say: 1) Parks are receiving acidic deposition with loadings highest in the east and southeast; 2) there is a potential for irreversible damage to sensitive cultural and natural resources in parks across the country; 3) these effects could be potentially catastrophic for high elevation lake and stream systems, particularly those with salmonid (trout) populations, high elevation boreal forests, and sensitive cultural resources; and 4) the NPS through its strong tie to the interagency research program will get the needed answers over time." (*Park Science*, Winter 1986).

A biomonitoring garden, Voyageurs NP. The garden is part of the Minnesota Environmental Board Plot System, which includes biomonitoring gardens throughout the state. Each garden consists of several species of native and crop plants. Biomonitoring studies are used to detect the first signs of air pollution effects on biological resources. Individuals in the photo are harvesting plants for dry weight and trace elements analyses. The NPS has established biomonitoring plots in several NPS units.

Engineering and Safety Services Division

Control of environmental pollution originating within parks is generally the responsibility of park maintenance staffs, which manage sewage treatment facilities, solid waste disposal, use of herbicides and pesticides, and other potential sources of pollution. The NPS record in meeting requirements of Federal, State, and local laws on environmental quality is excellent, but it can be argued that standards within parks, which are intended to be maintained in near-pristine condition, should be set even higher than those of the surrounding jurisdictions.

The Branch of Maintenance in the Washington office, a unit of the Engineering and Safety Services Division, has responsibility for Systemwide policy, budgets, guidelines, and planning for maintenance. It is currently conducting an inventory of waste chemicals in parks and investigation of methods for their disposal. It is also responsible for dealing with external hazardous waste situations that affect parks and come under the Resource Conservation and Recovery Act (RCRA—waste from present operations) or the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA/Superfund—inactive hazardous waste sites). Some currently identified problems include drums of toxic chemicals that wash ashore at Padre Island, impacts on Gateway National Recreation Area of toxic wastes from two New York City landfills, and radioactive wastes at a lake near the Appalachian Trail at Pauling, New York.

The Role of Non-NPS Institutions

At some parks, much of the funding for research on pollution problems is provided by non-NPS sources, which find the parks useful sites for answering their research questions. A March 1985 register of completed or ongoing research projects on environmental quality of Great Smoky Mountains National Park listed 103 projects. Of the 77 for which the funding source was recorded, 41 were funded wholly or in part by non-NPS institutions. In terms of total funding amounts, the non-NPS proportion was even larger. Of the 42 acid deposition/ecosystem studies underway in March 1986 in Sequoia National Park, 37 were sponsored wholly or in part by other institutions.

The Outlook

NPS resources devoted to improvement of environmental quality in the parks have been increasing over the past few years. Whether these resources are adequate or whether this trend will continue in the face of general budget cutbacks is uncertain. The problems, however, are likely to be with us for a long time.

Head of a bronze statue, "The Hiker," honoring soldiers of the Spanish-American War. One of 50 such statues in the U.S., this one, erected in Allentown, PA, in 1937, has suffered pitting on the face and streaking on the hat due to air pollution.

POLICY AND REGULATIONS

The Clean Air Act and National Parks

The Clean Air Act, 42 U.S.C. §§7401, *et. seq.*, augments the fundamental resource protection responsibilities of the National Park Service Organic Act with respect to the air quality and related values of park areas. Together, these authorities form the basis for the National Park Service's general policy of promoting and pursuing measures to safeguard the resources and values of units of the National Park System from the adverse impacts of air pollution.

The goal of the Clean Air Act (Act) is safe and acceptable ambient air quality through the attainment and maintenance of national ambient air quality standards. The "primary" standards are to protect the public health "with an adequate margin of safety," and the "secondary" standards are to protect the national "welfare"—defined to include the types of resources and values found in park areas—from all "known or anticipated adverse effects." These primary and secondary standards are air pollutant concentration levels set on the basis of scientific "criteria documents." The Environmental Protection Agency (EPA) has set national ambient air quality standards for six widespread pollutants: sulfur dioxide, particulate matter, carbon monoxide, ozone, nitrogen dioxide, and lead. State and local governments may set additional, and more stringent, standards.

At any time, a particular area may be "cleaner" or "dirtier" than the standards for these pollutants. The Act supplements its nationwide goal of attaining and maintaining these standards with specific goals for these "clean" and "dirty" areas. For the clean areas of the country, the Act seeks to "prevent the significant deterioration" (PSD) of the air quality, particularly in areas of special natural, recreational, scenic, or historic value. For the "dirty" or "nonattainment" areas of the country, the Act demands that "reasonable further progress" be made toward the attainment and maintenance of the primary and secondary standards.

In pursuit of these standards as well as the PSD and nonattainment goals, the Act imposes various performance and emission restrictions on individual sources. The Act uses the State Implementation Plan process as the measns to implement and enforce its goals and source restrictions.

The PSD title of the Act deserves particular discussion as a prime authority for protecting the resources of parks. In certain respects, Part C is a resource protection statute. One of its purposes is "to preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic, or historic value." PSD addresses resource protection through the establishment of ceilings on additional amounts of air pollution over baseline levels in clean air areas, the protection of the air quality related values of certain special areas, and additional protection for the visibility value of certain special areas.

More specifically, Part C reflects Congress' judgment that, among the clean air regions of the country, certain areas—the "class I" areas—deserve the highest level of air quality protection under the Act. Congress designated 158 areas as class I areas, including national parks over 6,000 acres and national wilderness areas over 5,000 acres, in existence on August 7, 1977.

In these class I areas, once "baseline" is triggered by submission of the first permit application from a major new source, Part C allows only the smallest "increment" of certain pollutants—to date, only sulfur dioxide and particulate matter—to be add-

ed to the air. In addition to these increment ceilings, PSD also establishes a site-specific resource test, known as the "adverse impact" test, to determine whether emissions from major new sources will cause an "adverse impact" on the "air quality related values" of the class I area. In the case of a major new source (or expansion), the adverse impact test works as follows:

- If the Federal Land Manager determines, and convinces the permitting authority, that the new source will adversely impact the class I area's resources—even though the new source's emissions will not contribute to an increment violation—a "PSD permit" shall not be issued.
- If the Federal Land Manager certifies that the new source will not adversely impact the class I area's resources—even though the new source's emissions will contribute to an increment violation—the permitting authority may issue a "PSD permit."

The adverse impact test imposes an "affirmative responsibility" on the Federal Land Manager "to protect the air quality related issues (including visibility)" of class I areas, and, as the Senate committee wrote, "[i]n the case of doubt, . . . [to] err on the side of protecting the air quality related values for future generations." "Air quality related values" include all values of an area dependent upon and affected by air quality, such as scenic, cultural, biological, and recreational resources, as well as visibility itself. The current working definition of "adverse impact" is any impact that:

- Diminishes the area's national significance, and/or
- Impairs the structure and functioning of ecosystems, and/or
- Impairs the quality of the visitor experience.

In addition to increment ceilings and the adverse impact test, Congress enacted one more resource protection measure for class I areas, namely, "visibility protection" for the 156 (of 158) statutory class I areas where visibility is an "important value." In Part C of the Act, "Congress . . . declares as a national goal the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory class I federal areas which impairment results from manmade air pollution." In this provision, Congress expressed the national desire to preserve, for its own sake, the ability to see long distances, entire panoramas, and specific features in the statutory class I areas. EPA is still developing the regulatory program to assure "reasonable progress" toward the national visibility goal. EPA has already issued regulations concerning new source review and visibility monitoring requirements, and is now working on regulations concerning "best available retrofit technology" for major existing sources that impair visibility in statutory class I areas as well as "long-term (10-15 year) strategies" for moving toward the national visibility goal. To date, EPA's rulemaking proposals have addressed only "plume blight" and other visibility impairment "reasonably attributable" to a specific source or sources. EPA has not yet proposed regulations to address visibility impairment from "regional haze."

As the above discussion demonstrates, the Act creates several opportunities and tools for protecting the resources and values of class I areas. New pollution after baseline in class I areas is generally limited to the small class I increment, the Federal Land Manager must determine whether major new sources will adversely impact the areas, and measures must be developed to protect the visibility of class I areas from manmade pollution impairment. The States must develop their PSD plans with Federal Land Manager consultation and a public hearing. Major new sources must undergo an equally public permit review, involving air quality monitoring; analysis of resource impacts; application of "best available control technology;" and effective emission ceilings based on the class I increment, national ambient standards, adverse impacts threshold, or possibly visibility impairment threshold, whichever is the lowest. Existing sources may be regulated to protect visibility or to remedy a violation of an increment, national ambient standard, or arguably class I resource protection.

Part C's concern for resource protection, however, is not limited to class I areas. Congress designated all other clean air regions of the country "class II." Congress further prohibited redesignation not only of statutory class I areas to any other classification, but also of certain class II areas to the "dirtier" class III classification. These so-called class II "floor" areas include the following areas when greater than ten thousand acres: national monuments, national primitive areas, national preserves, national recreation areas, national wild and scenic rivers, national wildlife refuges, national lakeshores and seashores; as well as national parks and wilderness areas established since August 7, 1977. Class II increment ceilings on additional pollution over baseline concentrations allow for moderate development in class II areas. Class II increments constitute an absolute ceiling on additional pollution in these areas, because Congress did not qualify the class II increment with an adverse impact test.

Although the Act does not create as many resource protection tools for class II areas as for class I areas, it nevertheless creates opportunities. The Federal Land Manager can participate in State Implementation Plan proceedings, new source reviews, and other federal, State, and local activities that potentially affect the air quality of their areas. As appropriate, the land manager can undertake or encourage efforts to redesignate the area to class I. Also, for units of the National Park System, the land manager can turn to the Organic Act for protection of park purposes and values from adverse air pollution impacts.

At this time, there are no "class III" areas. States or Indian governing bodies have the authority to redesignate to class III any clean air area except a statutory class I or class II "floor" area. Class III designation could allow for substantial air pollution increases over baseline in the area. The redesignation process itself, as well as subsequent new source reviews, provide opportunities for land managers to have their air quality concerns considered.

For parks that are in, or affected by, the "dirty regions" of the country where the national ambient air quality standards have not yet been met, the PSD provisions do not apply. Instead, the "nonattainment" requirements apply. As with class II and III areas, the Act does not establish an explicit role (other than consultation) for the land manager, but it does require public proceedings at various times. For example, the State must hold a public hearing prior to promulgating a nonattainment implementation plan, which is a plan for attaining all national ambient air quality standards "as expeditiously as practicable," most primary standards by 1982, and primary standards for ozone and carbon monoxide by 1987. The nonattainment plan must demonstrate "reasonable further progress" toward the national ambient standards in the interim; provide for reasonable available control technology on sources in the area; analyze effects on air quality, welfare, health, society, and economics; and require a public hearing prior to issuing a permit for a new source. To obtain a permit, new sources in urban areas must secure from other facilities "emission offsets" greater than the new source's proposed emissions; in addition, a new source's control technology must comply with the "lowest achievable emission rate" for such a source.

As a final word about the Clean Air Act, the above discussion suggests many provisions that, directly or indirectly, can address many air quality concerns in parks. However, the Act—at least as currently interpreted or implemented—does not address all such resource protection concerns. For example, the Act often does not deal effectively with the following concerns:

- The individual and cumulative air quality impacts of sources not subject to PSD permit requirements, such as "minor" sources, sources located in nonattainment areas, existing sources, and sources located in foreign countries;
- Regional loadings of air pollutants; and
- Long-range transport of air pollutants.

Despite these problems, the Act provides several effective approaches to park resource protection. Essential to making the existing statutory authority work for the protection of the resources, however, is the gathering and development of the relevant scientific and technical information on which the legal system depends.

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An NADP deposition monitor, Glacier NP. The "wet bucket" (with cover) is automatically uncovered when precipitation moistens a sensor.

Principal Laws and Regulations Concerning Water Quality

Clean Water Act

(Federal Water Pollution Control Act of 1972 and 1977 Amendments)

The Clean Water Act, one of the first major pieces of comprehensive environmental legislation, established a complete regulatory system for the protection of water quality in the United States. Unlike many earlier responses to environmental problems, the Clean Water Act is equally applicable to activities on both federal and private lands.

The Act has general goals to protect health, to enhance the quality of water and to provide water quality for the protection and propagation of fish, shellfish, and wildlife in and on the water and for agricultural, industrial, and recreational purposes. To meet these goals, the Congress established a system for limiting the discharge of pollutants into the waters of the United States through "effluent limitations;" that is, by limiting the amount or concentration of specified pollutants that may be discharged. The following outlines the major parts of the regulatory system:

Section 208—Non-Point Source Pollution. This section of the Act, in its requirements for looking at area-wide waste treatment strategies, requires that states identify non-point sources (sources not in a single, specific location) of pollution (such as silvicultural practices or agricultural erosion) and propose methods for controlling such pollution.

Sections 301 and 306—Effluent Limitations. These sections prohibit the discharge of pollutants without a permit and provide for effluent guidelines by industrial category. There are two different performance standards—"best control technology currently available" and "best available control technology economically achievable"--which must be met by point source dischargers.

Section 303—Water Quality Standards. These are rules set by the states for the use or uses to be made of a water body or segment and the water quality criteria necessary to protect that use or uses. Standards are enforceable and are developed through a process that takes into account social, legal, economic, and institutional considerations. They serve to establish water quality goals for specific water bodies and serve as the basis for water quality-based treatment controls.

Section 402—National Pollution Discharge Elimination System. This permit system requires that all point source dischargers have permits that specify the effluent limitations and standards that must be met.

Section 404—Dredge and Fill Permits. All activities that would result in the filling of wetlands or in dredging of the waters of the United States are subject to permits issued by the Army Corps of Engineers.

Outstanding National Resource Waters (40 CFR 131.12(a)(3)). These regulations specifically require that the states' implementation methods and anti-degradation policies must ensure that "where high quality waters constitute an outstanding National resource, such as *waters of National and State parks and wildlife refuges* and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected" (emphasis added). [Units of the National Park

System clearly qualify for consideration for designation under this standard and the National Park Service is pursuing such designations through various state procedures.]

Safe Drinking Water Act

Passed in 1974, the purpose of this act is to safeguard public water systems and to protect groundwater sources of drinking water.

Wild and Scenic Rivers Act

The Wild and Scenic Rivers system was established to preserve free-flowing rivers and their immediate environments for the benefit and enjoyment of present and future generations. The existence of a wild or scenic river does not abrogate any existing rights and privileges but prevents establishing new rights that would affect the river and its environs' suitability for this status.

Floodplain and Wetlands Executive Orders

The two executive orders are designed to ensure that activities undertaken in floodplains or associated with wetlands do not adversely affect public safety or natural resources.

Resource Conservation and Recovery Act (RCRA)

This act provides "cradle to grave" supervision for hazardous wastes. Implementation should prevent resource damage to NPS units that would have resulted without careful supervision of these pollutants.

Boundary Waters Treaties

These agreements require that waters flowing across national boundaries shall not be polluted on either side to the injury of health or property of the other.

Adequacy of Protection

Because the standards provided by the laws and regulations cited are nationwide in applicability and effect, it is difficult to say with any accuracy whether the protection provided is adequate for specific resource protection needs in specific NPS units. It is theoretically possible to require higher standards of performance for activities within NPS units where a clear connection between the existing standards and resource degradation can be demonstrated. The difficulties with this approach are twofold: one, scientific data of the quality necessary to establish an unequivocal nexus between the activity proposed and resource damage is difficult to come by and two, because of the exceptionally large number of permits issued by the states and EPA, it is difficult to know when permits are being issued. For these reasons, designations of specific national park waters as "outstanding national resource waters" could be important for providing a level of protection commensurate with the resource values contained in National Park System units.

Placer Mining— A Regulatory Issue

One of the major sources of impacts to water quality in units of the National Park System in Alaska, is placer mining for gold. This mining is associated with claims under the 1872 Mining Law that existed prior to establishment of the park units. Contrary to a common perception, Alaska placer mining is a large-scale operation. Because placer mining requires that the gravels of streambeds be physically displaced, the effects to stream biota and water dependent flora and fauna can be both extreme and adverse. Certain operating methods, including the use of sedimentation ponds, limiting the amount of water used in the mining process, and use of portable equipment, can limit the adverse impacts of placer mining.

Presently, the number of placer mines that will be approved for operation this year will be limited because of litigation. The National Park Service is preparing environmental impact statements on the cumulative effects of placer mining in three Alaska units, a necessary first step to settling the lawsuit.

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RESEARCH ACTIVITIES

Many studies in air and water quality are underway. This section presents some of the more important or pressing investigations. Since many of these are part of or relate to the National Acid Precipitation Assessment Program (NAPAP), a description of that program is in order. The program is organized into seven task groups: Emissions and Controls, Atmospheric Chemistry, Atmospheric Transport*, Atmospheric Deposition and Air Quality*, Aquatic Effects*, Terrestrial Effects*, and Materials Effects*. The Park Service is importantly involved with five of these (marked with asterisks).

The task groups on Atmospheric Chemistry, Atmospheric Transport, and Atmospheric Deposition and Air Quality seek to provide more credible scientific statements of how a specific source or set of sources contributes to the deposition in a given downwind region. Mathematical models exist to account for gross atmospheric transport, transformation, and deposition. The task groups are working on incorporating more realistic and definitive descriptions of all three processes into more sophisticated models. Empirical studies are underway both to test the models and to learn more about the processes.

The specific goals of the Task Group on Atmospheric Deposition and Air Quality are to 1) determine the spatial and temporal variations in the composition of atmospheric deposition within the U.S. through a nationwide monitoring network; 2) develop and improve methods for reliable measurement of wet and dry deposition; and 3) develop information on the composition of largely pollution-free atmospheric deposition through operation of deposition monitoring and research sites at remote locations throughout the world. The principal source of data in the United States is the National Trends Network (NTN), designed by the Task Group. This network of 150 stations includes many in the National Atmospheric Deposition Program (NADP) network begun by the State Agricultural Experiment Stations in 1978. Thirty-two NADP/NTN stations are located in national parks. No practical method exists for the direct routine measurement of dry deposition, which may be as, or even more, important an environmentally damaging factor than wet deposition. Testing of instruments to measure dry deposition is an important part of the Task Group's current work.

The purpose of the Aquatic Effects Task Group research is to quantify, nationwide, the effects of acid deposition on freshwater resources in the U.S. The two main types of effects emphasized are alterations of water quality and impacts on aquatic organisms. In 1985 the program involved the following: National Surface Water Survey (including sites in several national parks), Direct/Delayed Response Project, Investigation of Biological Processes, Human Health Effects Program, Evaluation of Mitigation Strategies, and Watershed Research. In 1986 the goals will emphasize biologically relevant effects and long- and short-term changes in surface water chemistry.

It has become evident that to understand the potential effects of acid deposition on a lake or stream, chemical processes occurring in the surrounding watershed must be considered. The hydrology, soils, geology, vegetation, and air quality of the watershed all are important determinants of the chemical characteristics of surface waters. Therefore, integrated watershed research involving both the Aquatic Effects and Terrestrial Effects task groups is underway.

Several watersheds in national parks are among those being studied.

Research of the Terrestrial Effects Task Group is directed mainly at the response of vegetation to acid deposition and terrestrial-aquatic linkages. The key questions are: 1) What are the effects of atmospheric deposition on forest structure and function, and how is the response related to soil, biotic, and climatic factors? and 2) How does the terrestrial system alter the deposition chemistry as precipitation flows to ground water, streams, and lakes? The recent decline of certain forest types in the eastern United States adds urgency to these questions. The watershed projects in national parks are among those seeking answers, as is a regional cooperative study in the southern Appalachians, described in the section, Terrestrial Effects of Air Polllution. Also described there are some related findings from the NPS Air Quality Division Biological Effects Program.

The Task Group on Materials Effects seeks to answer five key research questions:

A forest fire in Coconino National Forest, northern Arizona, produces a particulate carbon plume. Smoke from fires—natural or prescribed— causes a visibility problem in some NPS areas as well.

1) What roles do acid deposition and its precursors play in materials degradation relative to other natural and anthropogenic damage agents? 2) What is the rate of damage to specific materials as a function of specific pollutant levels? 3) What is the geographic distribution of susceptible materials? 4) What is the economic value of materials damage? 5) What protection and mitigation strategies are feasible? National Park Service participation in this work is described under Materials Effects of Air Pollution, below.

The NPS representatives on NAPAP task groups are:

Atmospheric Transport: Donald Henderson, Air Quality Division, Denver, Colorado

Atmospheric Deposition and Air Quality: Dr. William Malm, Air Quality Division, Ft. Collins, Colorado

Terrestrial Effects: Dr. Peter White, CPSU, University of Tennessee

Aquatic Effects: Dr. Gary Larson, CPSU, Oregon State University

Materials Effects: Susan Sherwood, Preservation Assistance Division, Washington, D.C.

Atmospheric Processes

Recent NPS research on atmospheric processes has emphasized development of models of air pollutant transport, and smoke management studies at Grand Canyon.

Regional Sulfur and Oxidant Modeling

The Air Quality Division has contracted research over the past 6 years to develop and test mathematical models to be used for assessing long distance transport of man-made pollutants. A model (RTM-II) was developed to simulate sulfur dioxide and sulfate concentrations in four national parks (Acadia, Great Smoky Mountains, Mammoth Cave, and Shenandoah). (See *Park Science*, Winter 1985, p. 6-8). A local transport and dispersion model is being applied in Shenandoah National Park. This local model will be coupled with the long-range transport model. By using a combination of the two models, the contribution of local, as well as far distant, air pollution sources to pollution buildup in the park can be evaluated.

Another version of the long-distance transport model (RTM-III) has been developed for predicting the distribution of photochemical oxidants. Evaluation and testing studies have been made using the Electric Power Research Institute (EPRI) Sulfate Regional Experiment data which were collected at nine stations in the eastern United States.

The model has been applied in a 31-state region of the eastern United States. These results provide ozone concentration estimates for the period July 16-23, 1978. From these results, ozone concentrations have been estimated for this time period in the same four parks to which RTM-II was applied. Ozone concentrations during this brief period are near the one-hour standard of .12 ppm.

An improved version of the model is currently being applied for a smaller area encompassing Shenandoah National Park. For this application a reactive plume model (RPM) is being incorporated into the regional model so the contribution of single sources to the total pollution burden may be assessed. The improved version of the model is being applied to the Central Valley of California to estimate ozone concentrations in Sequoia, Kings Canyon, and Yosemite national parks. The model results from the above applications will be used by the National Park Service to assist with the assessment of observed injury to vegetation, evaluation of acidic deposition, and visibility impairment in the national parks.

The model has received considerable recognition, even outside the United States. It is currently being applied in western Europe, and plans are in progress to apply it in some Canadian provinces. Other Federal agencies have also shown interest in using the model. The Environmental Protection Agency has had the model applied in the central United States to estimate ozone concentrations in agricultural areas. They also have indicated an interest in working with the National Park Service on the above mentioned Central Valley study to estimate ozone concentrations in agricultural areas of the Central Valley.

Donald Henderson
Air Quality Division
Denver, Colorado

Smoke Management

The smoke management studies are being conducted at Grand Canyon NP to advise park managers on the best weather conditions under which to carry out prescribed fires, which in the past have sometimes contributed to reduced visibility in the Canyon, and which could produce smoke drifting into the town of Tusayan on the South Rim. A conceptual model for the mean air motions in the Grand Canyon was developed using existing knowledge of airflow over cavities and abrupt steps, and available wind data. The model was tested with data produced by three wind sensors placed in or near the Canyon and by 39 pilot balloon launches within the Canyon. Some measurements important to understanding the airflow have also been made from aircraft and final recommendations await analysis of these additional data. Preliminary conclusions are that burning should be conducted only during periods when air above and within the Canyon is interacting, not when stable air fills the Canyon. Adverse conditions could be forecast using standard synoptic-scale data plus meteorological information from the Canyon rim and Tonto Plateau. To diminish drift of smoke into the town, most burning should be restricted to periods of southerly airflow and as much as possible to times before sunset.

Visibility and Particulate Monitoring

The NPS Air Quality Division has been monitoring visibility and particulates that affect visibility at more than 30 park sites. It has also studied the influence of visibility impairment on visitor enjoyment and use of park resources.

Visibility is recorded with both color photography and teleradiometry. The color photography documents the important elements of the scene and how they vary with changing air pollution levels, weather conditions, and sunlight. Teleradiometry uses a special telescope to measure the contrast between the sky in the background and dark landscape features so that changes in contrast caused by pollution or climatic changes can be recorded. Together, the photography and teleradiometry can be used to establish standard visual ranges—the distance from an observer at which a large dark object such as a forested mountain would just disappear against the horizon.

Results to date of visibility monitoring include the following: 1) More than 90 percent of the time, manmade pollution affected scenic views at all NPS monitoring sites. 2) The best average visibility is in northern Nevada, Utah, and southern Idaho. Next best is the Colorado Plateau, where Grand Canyon, Bryce Canyon, and Canyonlands national parks are located. 3) The lowest visibility in the West is in the coastal areas of California and Washington, probably because of natural weather conditions and smoke from prescribed burns. 4) The worst visibility recorded by NPS is in the eastern United States, where relative humidity and air pollution levels are highest. In the summer of 1983, for instance, the median visibility range at Shenandoah National Park was 19 kilometers, as compared with 100 to 200 kilometers for most western parks. 5) Visibility is generally best in the winter and worst in the summer.

A ranger removes the air filter from a fine particulate stacked filter at Bandelier NM, one of 30 sites in the NPS visibility monitoring network.

Particulates are monitored through the use of stacked filter samplers. Samples are collected over 72-hour periods which are followed by 12 hours off. NPS research and monitoring indicate that particulates are the major contributor to visibility impairment in parks; especially the very fine particulates (those smaller than 2.5 micrometers in diameter), which scatter light much more effectively than do large particles, which form a large percentage of the pollution mass. Sulfates, the end product of atmospheric chemical transformation of gaseous sulfur dioxide, formed the largest single fraction of the total collected fine particle mass and were the principal impairer of visibility everywhere except in the Northwest, where carbon particles took the lead. On the Colorado Plateau, sulfate particles were responsible for 40 to 65 percent of the visibility impairment and at Shenandoah National Park for over 70 percent. In the Southwest, windblown dust, emissions from construction activities, and traffic on unpaved roads contributed 10 to 30 percent of the visibility reduction, while fine-

particle carbons and nitrates accounted for another 20 percent. (The above information was taken largely from "Pollution Where You'd Least Expect It," by David B. Joseph, *EPA Journal*, March 1986.)

The NPS has studied the influence of visibility on visitor enjoyment of parks through mail-back surveys and on-site interviews. Mail-back surveys to determine which park attributes visitors feel are most essential to a positive experience were conducted at Grand Canyon, Mesa Verde, Mount Rainier, and Great Smoky Mountains national parks during the summers of 1983 and 1984. The results indicated that visitors felt a natural environment, free of pollution and undisturbed by humans was most important to their experience. On-site interviews at Grand Canyon and Mesa Verde were conducted to examine effects visual air quality might have on the recreational experience sought. Seventy-six percent of the visitors interviewed at Grand Canyon said they saw haze and at Mesa Verde, 86 percent. As visitors became more aware of haze, they reported decreased enjoyment of the view and less satisfaction with visual air quality. At the same time, 80 percent or more of the visitors thought the haze was natural, while monitoring showed that 60 to 80 percent of the haze was associated with urban and industrial sources. This suggests the need for expanded interpretation and public education on the state of air quality in parks.

The Park Service is also involved in two cooperative programs to study visibility. The SCENES program is a multi-year research and monitoring investigation of the layered and regional haze problem in the Southwest. SCENES is an acronym for Subregional Cooperative Electric Utility, National Park Service, and Environmental Protection Agency Study. Electric utilities participating in the study are Salt River Project, Southern California Edison, and Electric Power Research Institute. The Department of Defense is also participating. The goal is to establish the relative contributions of various source categories to atmospheric aerosols in the desert southwest, with emphasis on national parks and recreation areas in Arizona and southern Utah and restricted airspace in the western Mohave Desert. Over a dozen monitoring sites have been established. Most are at remote locations designed to monitor regional atmospheric constituents through both optical and aerosol measurements. Field measurements were begun in 1984 and will continue for at least 5 years.

The second cooperative program is IMPROVE (Interagency Monitoring of Protected Visual Environments). Begun in FY1985 (planning only), this program will conduct long-term visibility measurements in national parks, national monuments, and wilderness areas, as required by an EPA regulation written to help carry out objectives of the Clean Air Act. The monitoring program must determine the background visibility conditions in and around the mandatory class I areas and document the extent of any visibility impairment in those areas that can be attributed to a source or group of sources. All class I areas in the United States will be grouped in visibility regions (tentatively 23). Each region will have one monitoring site representative of all the class I areas in that region. Each site will employ, at a minimum, an automatic teleradiometer, an automatically-actuated 35 mm camera, an SFU particle sampler, and a data collection device to record values from the teleradiometer. The network, under general responsibility of EPA, will consist of 15 NPS sites, 4 U.S. Forest Service sites, and 4 U.S. Fish and Wildlife Service sites. Field measurements are scheduled to begin in FY1986.

Watershed Projects

Integrated studies of the effects of atmospheric pollutants, especially acidic deposition, on ecosystems of small watersheds are being conducted in five national parks. Those at Sequoia, Olympic, Rocky Mountain, and Isle Royale are funded through NAPAP, with additional funding sources at Sequoia. Studies at Shenandoah are funded primarily by EPA. Each watershed project meets certain core requirements—types of measurements that can be compared among projects—as well as conducts other research that may be unique to the project. Other parks that are interested in setting up such watershed studies should contact one of the watershed project coordinators, listed below.

Sequoia National Park: Dr. David Parsons
Olympic National Park: Dr. John Aho
Rocky Mountain National Park: Dr. Jill Baron
Isle Royale National Park: Dr. Robert Stottlemyer
Shenandoah National Park: Dr. James Galloway (Univ. of Virginia)

NAPAP is in the process of developing a questionnaire for gathering information about existing watershed sites that are being monitored. Their goal is to document existing programs and determine what is being monitored, for how long, and what methods are used. This effort will document NAPAP and non-NAPAP sites. This is strictly an informational exercise to be used by those needing to know where monitoring/research is being done that may be relevant to overall NAPAP program goals. The exercise may be helpful for direct future expansion of the program into appropriate existing projects, rather than starting new ones.

Sequoia National Park

The Sequoia National Park acid deposition project is a long term, interdisciplinary, multi-agency study of the effects of acid precipitation on natural ecosystems. The program collects baseline data on ecosystem processes necessary to detect subtle but potentially devastating changes in natural communities. The project is conducted both under the auspices of the National Acid Precipitation Assessment Program (NAPAP) and as a cooperative program with the California Air Resources Board.

In recent years there has been growing concern over the potential effects of atmospheric pollutants in California. However, without adequate baseline data it will be impossible to assess future changes in atmospheric inputs and their effects on natural ecosystems. The NPS is cooperating in this study with federal and state agencies and private organizations to quantify some pollutant inputs and selected ecosystem properties across a 2200 m elevation gradient in the southern Sierra Nevada of California. The study is designed to produce baseline ecological and input data. Specific studies include analysis of precipitation chemistry, atmospheric chemistry, aquatic chemistry and biology, soil chemistry, nutrient fluxes, vegetation structure and function, and impacts of oxidant air pollutants (ozone). The potential role of fire—a frequent natural occurrence in the area—in buffering the effects of acidic inputs will also be evaluated.

The study has successfully attracted the support and financial involvement of a number of federal, state, and private agencies. These include the California Air Resources Board, the U.S. Geological Survey, the U.S. Forest Service, NASA-Ames Space Flight Center, the University of California, the Electric Power Research Institute, the Southern California Edison Company, and the National Park Service. As a result of such interest, the program has rapidly developed into one of the most comprehensive ecosystem studies ever attempted in the State of California.

The principal goal of the Sequoia program is to develop baseline values for selected biogeochemical processes and aspects of ecosystem structure and function that are believed sensitive to acid precipitation and other anthropogenic pollutants. A first approximation of input/output budgets of water, hydrogen, and nitrogen for each of the study sites (watersheds) will also be obtained. Development of specific objectives for each of the many subprojects included in the program is the responsibility of the individual principal investigators.

Three primary study sites have been selected for intensive investigation. Spanning much of the local elevation gradient, the sites include low elevation chaparral, middle elevation mixed conifer forest, and high elevation subalpine communities. All of the sites are situated within the drainage

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of the Middle Fork of the Kaweah River. Each site consists of a headwater drainage basin or watershed that is located distant from development and sources of local contamination. Extensive soil, vegetation, and lake surveys were used to assure that watersheds selected were representative of ecosystems of the southern Sierra Nevada.

At each primary study site, the following baseline measurements are made: meteorology; aspects of atmospheric chemistry, quantity and chemistry of rain and snow (Aerochem-metric weekly event samplers and bulk samplers at all sites, snow buckets, lysimeters and/or cores at the middle and high elevation sites); soil characterization and mapping; soil chemistry; stream discharge (quantity and chemistry); stream periphyton and invertebrate monitoring; litter accumulation and decomposition rates; nutrient fluxes; vegetation composition, phenology, productivity, biomass, and water stress; and plant tissue and soil nutrient analysis. The low elevation Elk Creek site is the focus of additional studies on dry deposition and throughfall chemistry. The middle elevation Log Meadow site is the focus of additional studies on forest productivity and biomass, root production, N mineralization rates, and ozone effects. The high elevation Emerald Lake site is the focus of studies on lake dynamics (physical, chemical, and biological aspects), lake sediment buffering, soil/water interactions, detailed snow hydrology and chemistry, and tree ring analyses of growth rates and trace element levels.

The Park staff has worked together with the California Air Resources Board and other cooperators to identify study priorities and assure integration of individual projects. The National Park Service has given high priority to providing a framework that would be attractive to potential cooperators. This has included development of the Southern Sierra Research Center (laboratory, office, and dormitory facilities) as well as a cadre of trained technicians available to assist in routine data collection activities. The Park staff has taken the responsibility for data collection in the areas of meteorology, precipitation chemistry, stream chemistry and hydrology, forest insects and disease, litter dynamics, and baseline vegetation plots. Other projects have been carried out either under contract or by cooperative agreement with university scientists or other federal and state agencies.

Findings to date document the occurrence of acidic precipitation and the existence of extremely sensitive ecosystems. While winter precipitation generally falls as relatively unpolluted snow, the occasional summer and fall storms that occur in the area contribute potentially significant pulses of hydrogen, sulfate, and nitrate. The granitic bedrock, thin soils, and alkaline lakes that characterize the Park have a low buffering capacity and thus are extremely sensitive to acidic inputs. Additional studies on the quantity and type of dry deposition occurring in the Park are needed to fully document deposition inputs.

David Parsons
Research Scientist
Sequoia-Kings Canyon
National Parks

Olympic National Park

Information on ecosystem processes from Olympic National Park, where air pollution presently is minimal, will provide valuable baseline reference levels with which to compare acid deposition effects in other regions of North America, as well as with future effects here. The watershed studies in Olympic, contracted by NPS to the College of Forest Resources, University of Washington, were begun in 1984 and will run until FY1992.

The watershed of the main fork of the Hoh River (299 sq mi, about 60 percent within the park) was chosen as the geographic focus of this research. Because of the large area and the biological diversity represented, the more intensive aspects of the study are being conducted in smaller watersheds representative of major vegetation zones present within the main Hoh drainage. The hypothesis is that the chemistry of the Hoh River is a composite result of biogeochemical processes operating on many smaller units.

If, or when, pollution effects produce a response sufficient to be detected in drainage waters, the effect will probably not be uniform. Some vegetation types potentially are more sensitive to altered input chemistry than others. By focusing research on points near the source, changes in ecosystem function in the fragile subalpine areas, for example, will be detected before changes in chemistry of the Hoh River itself.

Two smaller watersheds are currently being studied: West Twin Creek (elevation 505-2800 ft; Sitka spruce-red cedar-western hemlock old growth rain forest, nearly closed canopy); and Hoh Lake basin (elevation 4100-5000 ft; silver fir forest, undisturbed, more exposure than at West Twin Creek). Both have basic vegetation community maps, permanent sample plots, a sustained history of scientific study, and a meteorological station (measuring relative humidity, air temperature, soil temperature at 8'' and 20'', insolation (pyranometer), windspeed and direction, and rainfall amounts and duration of events). Surface water chemistry is being monitored. In addition, the Twin Creek site, established during the first season of field work in 1984, has a permanent stream gauge, and an array of precipitation collectors to allow comparison of chemistry of direct precipitation, stemflow, and throughfall (drip) to the chemistry of surface water of Twin Creek.

On the permanent sample plots, soils will be described, and measurements will be made of all trees larger than 5 cm in diameter at breast height, samples of understory vegetation, litterfall rates, biomass and production, and nutrient cycling. A related study in the Hoh River valley by researchers from the Department of Forest Science, Oregon State University is monitoring lichen productivity, moss productivity, canopy litter fall, leaf litter decay, and conifer needle retention times. Together these studies will establish the range of natural variation in Hoh valley ecosystems, so that effects of human influences such as air pollution can be identified.

Rocky Mountain National Park

Loch Vale Watershed in Rocky Mountain National Park has been the subject of intense scrutiny since 1981. The NPS has been investigating whether there is an acidic deposition problem, and how acidic deposition affects high elevation ecosystems of the southern Rocky Mountains. The first question was addressed by reconstructing lake and atmospheric chemistries from lake sediments and combining that with knowledge of current deposition chemistry. The conclusion was that there has been no discernible trend toward increasing acidity in either lakes or deposition over the past 150 years, and current deposition chemistry, while exhibiting some industrial and automotive influence, is not yet acidic enough to cause ecological damage. The values of acid, sulfate, and nitrate deposition are still well below the levels known to have been responsible for effects elsewhere in the world. The results of this work are published (*Water Resources Bulletin* and *Water, Air, Soil Pollution*) or in press (*Canadian Journal of Fisheries and Aquatic Science*). The latter should be in print by early summer. (See Recent Publications)

In 1982 Loch Vale Watershed (an NADP site) was instrumented with an acid deposition collector, a weather station, a flume to quantify stream flow, and a number of smaller instruments to measure ecosystem processes that might help to mitigate acidic deposition. An intense sampling program was initiated with the help of the U.S. Geological Survey, U.S. Forest Service, Bureau of Reclamation, Solar Energy Research Institute, and Environmental Protection Agency. Measurements are taken on the chemistry of lakes and streams, soils, vegetation, rain, throughfall, snow, and bedrock minerals. Some of the more important results are discussed below.

The high elevation ecosystems of Rocky Mountain National Park are among the most sensitive to acidification of any in the world. The alpine and subalpine lakes are

surrounded by slow-weathering granitic bedrock, thin to nonexistent soils, and little or no vegetation. These ingredients add up to a minimal source of buffering capacity with which to counter increasing acidity. Lakes and streams reflect this with alkalinity values averaging 60 microequivalents/liter over a normal water year. Many lakes within Rocky Mountain NP support healthy populations of trout, and streams show a diverse community of benthic macroinvertebrates. The sensitivity of these lake systems is further increased by the strong seasonality of inputs. Deposition may build up in the snowpack for up to seven months of the year, then melt out in a very short time. Currently, with only a slight increase in atmospheric deposition of acids, spring pH values drop as low as 5.7, a value not much above the threshold for biological effects.

Other factors which restrict the ability to withstand an increase in acidic deposition are complex. Because these high elevation systems (often over 3000m elevation) are so cold and are stressed by a short growing season, lack of sufficient moisture, and dessicating high winds, they do not seem to be limited by lack of the nutrient nitrogen. Consequently, increased NO3 in deposition (a result largely of automotive emissions and industrial combustion of oil or coal) may cause increased acidity in lakes and streams, just as SO4 will cause loss of acid neutralizing capacity. Soils in these very cold environments accumulate a lot of organic matter because temperature and moisture regimes prevent rapid decomposition. These soils are already very acidic, with low base recharging capability and low sulfate adsorption capacity. There will be very little replenishment of lake and stream neutralizing capacity from soils. Similarly, bedrock minerals will not provide much buffering, and in-lake processes do not seem to be a source of acid neutralizers.

These results, which have been determined empirically, correlate well with another method of ecosystem analysis employed: systems analysis with computer models. Researchers are currently working with a model developed at the University of Virginia called MAGIC (Model of Acidification of Groundwater in Catchments). The model was first tested on data collected from Shenandoah National Park. This model, which was developed for an environment with a lot of soil and no yearly accumulation of snow, works fairly well in Rocky Mountain NP, in spite of these drawbacks. Portions of it are being modified to better reflect western conditions.

All of this could have important implications for the management of Rocky Mountain National Park. Here is an ecosystem that is very sensitive to acidic deposition but which is not yet affected. Its location in the southern Rockies puts it near growing urbanization, smelting of copper and other metals, and the possible development of oil shale and natural gas facilities. The chances of atmospheric deposition causing biological effects here in the future are great. With improvement in the computer modeling, it may be possible to make educated guesses about how long it will take for effects to occur given different deposition scenarios. This allows Park managers possibly to prevent the damage before it occurs by offering convincing evidence of how, when, and why. The loss of trout populations, for instance, would be a severe blow to Rocky Mountain National Park. This research may be one way to see that it doesn't occur.

Jill Baron
Applied Research Unit
Water Resources Division
Fort Collins, Colorado

Isle Royale National Park

This project was initiated in June 1982. Four watershed/lake ecosystems are under study: two on Isle Royale and two on the Upper Peninsula of Michigan. The two on Isle Royale are similar in character except for glacial till composition and water chemistry, and are representative of systems in this national park. These watersheds are dominated by boreal forest. Research shows that the two Isle Royale lakes are not directly sensitive to anthropic acidification. The Upper Peninsula sites are sensitive to present levels of acid inputs. They differ from the Isle Royale sites in geological substrate, and are forested with northern hardwoods.

Routine meteorological data are collected on all sites. Stream discharge into and from the lakes is measured. Periodic baseline measurements are made every 5 years on each site. These include: plant biomass and biomass components, forest litter, soils, and plant community composition. The lakes are sampled seasonally at multiple depths and at multiple stations. Temperature, light, and chemical profiles are determined, and primary productivity and chlorophyll *a* measured. Color, pH, alkalinity, specific conductance, macro ions, total nitrogen, and trace metals are determined on most lake and streamwater samples. Research projects include analysis of lake sediment cores; precipitation modification by forest canopy, litter layer, and soil in both vegetation types; nitrogen budgets as affected by *Alnus* (alder) and beaver activity; forest soil anion mobility; and snowpack nutrient accumulation and ionic movements. Most sample analyses and data processing are conducted at Michigan Technological University.

In 1985, a four-year study of lake primary productivity and chlorophyll was ended. The results are considered valuable in themselves, especially in this region, but recent research has found that this kind of study is not a good indicator of ecosystem change, certainly over periods of less than 10 years. NAPAP-related research is presently focusing on the following topics: snowpack ionic loading and dynamics in a small first-order watershed (underway for seven years, probably one of the longest intensive snow quality/ionic movement records in the nation—paper submitted); sulfate anion mobility in boreal and northern hardwood forests (papers submitted); qualitative relationships among canopy throughfall, soil solution, and lake water chemistry in a very sensitive aquatic ecosystem; completion of a nutrient cycling study in a boreal forested ecosystem; and a study of a gradient of anthropic atmospheric inputs to national parks of the Great Lakes Basin (paper submitted). There will be an attempt next winter to plug data into an existing watershed model for testing.

Shenandoah National Park

The Shenandoah Watershed Study (SWAS) was initiated in 1979 as a cooperative research program of Shenandoah National Park and the Department of Environmental Sciences at the University of Virginia. The objective of SWAS, in broad terms, is to understand the processes that govern biogeochemical cycles in forested watersheds. More specifically, the primary research emphasis has been determined by the need to assess watershed response to the deposition of atmospheric acid.

The principal investigators of SWAS are Dr. Jack Cosby, ecosystem modeler; Dr. Jim Galloway, aquatic chemist; Dr. George Hornberger, hydrologist; Dr. Hank Shugart, forest ecologist; and Dr. John Sigmon, forest meterologist.

From both a scientific and a resource management perspective, the SWAS has been informative. Of principal importance, SWAS research has identified a combination of watershed sensitivity and elevated acid deposition which results in a poor prognosis for large areas of Shenandoah NP.

The concentration of sulfate in precipitation, for example, provides a measure of the anthropogenic component of acid deposition. Compared with remote areas of the world, the current loading of atmospheric sulfate to this part of the Blue Ridge Mountains is conservatively estimated to be about ten times preindustrial levels. This amounts to about 25 lbs. of wet deposited sulfate per acre per year in Shenandoah NP—one of the highest acid deposition levels received by any of the national parks.

This elevated acid influx is made critical by the lack of buffering capacity associated with many of the soils and streams in the area. Approximately one third of the Shenandoah NP watersheds have been identified as susceptible to acidification. Streams draining these watersheds have alkalinity values less than 100 ueq/L (or about 5.0 mg/L), well below commonly cited sensitivity criteria. Our current prediction is that these streams will be subject to significant reductions in pH and alkalinity over

the next few decades—with coincident loss of indigenous eastern brook trout populations.

SWAS has taken a threefold approach to understanding controls on both aquatic and terrestrial response to elevated acid deposition. The first approach treats watersheds as units by measuring their inputs (atmospheric deposition) and outputs (stream discharge) to determine the net effect of the watershed processes. This information is then used to formulate explanatory hypotheses. The second approach uses laboratory and field experiments to test the hypotheses formulated from the results of the input-output studies. The third approach applies the previous results to create models that predict watershed response and impacts.

The information needed to establish input-output budgets, both in terms of net loadings and temporal variation, has been provided by monitoring the quantity and chemistry of precipitation and stream discharge at the White Oak Run and Deep Run watersheds over the past 6 years. These watersheds, located in the Park's southern section, are underlain by relatively inert quartzites, sandstones, and phyllitic shales. A third watershed, the North Fork of Dry Run, which is associated with granitic bedrock in the Park's central section, has recently been adopted into the routine monitoring program.

Field and laboratory studies associated with SWAS have ranged in scale from park-wide surveys of stream chemistry to laboratory studies of soil properties. Major research areas addressed by individual projects over the previous 6 years have included: the control of stream chemistry by watershed characteristics such as bedrock, soil type, and vegetation; the acid neutralization and sulfate retention properties of watershed soils; the mobility of aluminum in soil and streamwater; and the hydrologic controls of the study area.

Currently the SWAS effort is expanding to include establishment of monitored terrestrial sites for integrated soil and vegetation studies. This work, in the North Fork Dry Run area, is coordinated with construction of above-canopy towers to facilitate intensive study of elemental exchange between the atmosphere and the forest system. Three aluminum towers, placed on an elevational gradient within the watershed, have been equipped with sampling systems and micrometeorological instrumentation designed to measure elemental fluxes in solution, gaseous, and solid particulate phases.

An overall integrating factor for SWAS has been the development of MAGIC, a computer model which is a process-oriented, intermediate-complexity model of watershed acidification. This model, which incorporates our present understanding of the most important controls on watershed response, can be applied to explain current watershed stream chemistry, and to predict future changes in streamwater chemistry under a range of future acid deposition scenarios.

A ranger at Canyonlands NP takes visibility measurements with a teleradiometer.

The bleak prediction that one third of Shenandoah NP streams will suffer acidification over the next few decades is based on the assumption of no change from current acid deposition levels. The MAGIC model indicates that substantial reductions in acid deposition will be required to reverse this trend. Even an immediate 50 percent reduction, for example, may be insufficient to achieve more than a delay in the acidification process. Acid deposition levels would still be elevated compared to preindustrial background levels.

Because of the significance of these predictions, refinement of the MAGIC model has assumed principal importance to the SWAS effort. A second generation of SWAS research within Shenandoah NP focuses on the need to reduce uncertainties in model structure and parameter specification. In addition, the application of the model to watersheds and regions in other areas of the country is being evaluated.

More information concerning SWAS research can be obtained by writing the Shenandoah Watershed Study, Clark Hall, Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22903, or by calling (804) 924-0603.

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Other Water Quality Research and Monitoring

Many other water quality studies are looking at the effects of pollution that enters streams, lakes, and groundwater directly from land-based sources, and at methods of control. Acid mine drainage, leachate from landfills, and nutrient loading from agricultural runoff are examples of problems being investigated. A few studies are highlighted below.

Friendship Hill National Historic Site

This one-square-mile area lies in a bend of the Monongahela River in southwestern Pennsylvania. Polluted water coming from an abandoned coal shaft at the upper boundary of the park forms the headwaters of a small stream that flows for about a mile through the park. This coffee-colored stream is extremely acidic (2.6 pH), has high concentrations of metals, supports virtually no aquatic life, and has killed trees and other vegetation growing along its banks or on overflow areas. Routine chemical and engineering abatement procedures were considered impractical or economically unfeasible. Instead, an artificial bog is being tested to act as a biological filter to improve water quality—a technique that has proved useful elsewhere.

Under supervision of Robert Kleinman of the U.S. Bureau of Mines, the project in its first year included studies of water and soil chemistry, water flow rates, and vegetation tolerance of the water and soil characteristics. Some of the stream's flow was diverted through a vegetated area, and two species

of sphagnum moss were tested in a plexiglass experimental bog tank. *Sphagnum recurvum*, cattail (*Typhus latifolia*), and several sedges and grasses did not appear to have been injured by exposure to the acid mine drainage. Water chemistry data from sample points along the water diversion indicated that acidity, total iron, sulfate, calcium, magnesium, aluminum, and specific conductivity measurements were lowered. If further experimental plots are successful, a full-scale artificial bog will be established.

Everglades National Park

The quantity, timing, and quality of water flowing into Everglades is a life and death matter for this largely marsh and mangrove park. One concern is the possibility of increased nutrient loadings in water reaching the park from agricultural areas to the north, and from backpumping of water from settled areas to the east in the event of a water shortage. This prompted the NPS Water Resources Division to study the effects of increased nutrients in the Shark River Slough, the largest freshwater flow system in the park. Three experimental channels were set up. One received increased phosphate-phosphorus and nitrate-nitrogen loading from April 1983 through September 1984. Another received only additional phosphate-phosphorus, October 1983 through September 1984; and the third received only nitrate-nitrogen during the latter period. The results indicated that even minor increases in phosphate-phosphorus loading can trigger major changes in periphyton (attached algae) and macrophyte (larger plant) biomass and community structure. Increases in nitrate-nitrogen may trigger more subtle responses in periphyton and macrophyte biomass and community structure. These changes, in turn, may potentially alter higher levels of ecosystem organization. While present nutrient loadings are not a problem in Everglades National Park, this study indicated that higher levels could create one.

Water Quality Monitoring Strategies in Two NPS Units

More than 160 units of the national park system may be affected by degraded water quality, but in many cases adequate resources are not available to conduct detailed hydrologic or limnological research. In such situations, a strategy for water quality reconnaissance and monitoring using a small number of parameters directly affected by specific activities in the watershed, is most appropriate. The results of these monitoring efforts can then be used to develop management alternatives and to assess the need for more intensive studies. Involvement of park resources management staff, as opposed to the contracting of entire programs to outside entities, both saves money and helps integrate water quality planning into the operational resource management activities of the park unit.

Programs of two NPS areas illustrate this approach. At **Big Thicket National Preserve**, the principal activities that degrade water quality are oil and gas development, sewage effluent discharge, and local timber operations. Monitoring is restricted to a few parameters associated with these activities. Analysis of certain types of samples is conducted at a park laboratory and of other types at a contract lab. It has been possible to establish a water quality program responsive to Preserve needs for about $15,000 per year plus staff support. At **Big South Fork National River and Recreational Area**, parameters directly related to acid mine drainage, oil and gas activity, domestic wastes, and watershed disturbance were selected for monitoring. Because of the remote location, a staff hydrologist was hired in 1982 to establish a water quality laboratory and conduct the monitoring program. Analysis of the first two years of data, collected from more than 30 stations, indicates that the park can be categorized into five major water quality types ranging from undisturbed to severely polluted. With the areal extent of each category in hand, park managers now can identify areas needing further research and can formulate management alternatives to help improve water quality.

Rocky Mountain National Park

Surveys of the distribution of *Giardia*, a protozoan parasite, in high-elevation streams of Rocky Mountain National Park were conducted during the summers of 1984 and 1985. In the Glacier Gorge and Loch Vale basins—two popular watersheds—3 to 11 *Giardia* cysts per 1000 liters were found in 7 of the 35 stream pumpings. In two of three remote backcountry streams sampled, no *Giardia* cysts were found; samples taken from the third stream contained cysts (10-16 per 1000 liters) only in the vicinity of beaver activity. Evidence to date suggests that in Rocky Mountain NP beavers, humans, and possibly muskrats are the principal carriers of *Giardia*, which causes a gastrointestinal illness that can be debilitating and long-lasting if not identified and treated. Park signs and brochures warn visitors of the danger and advise backcountry hikers to boil drinking water. *Giardia*, a cosmopolitan parasite, has also been identified in other western national parks, including Olympic, Sequoia, and Yosemite.

Olympic National Park

Crescent Lake in Olympic NP is surrounded by substantial residential and concession development. There is concern that these activities are adding to the nutrient loading of the lake and are accelerating the eutrophication process. An investigation is beginning this summer that will assess the trophic status of the lake and determine the nutrient status.

Toxic Chemicals

Toxic chemicals from the Cortese Landfill in New York are leaching into the waters of the **Upper Delaware Scenic and Recreational River**. A comprehensive effort is underway to assess the effects of the contaminants on aquatic life and to see if the local fish have accumulated the contaminants and pose a threat to people who eat them. Because the rate of leaching from this landfill is not known, the NPS perceives a need for the development and application of a long-term monitoring tool.

Fort Darcy, at **Richmond National Battlefield Park**, contains an old landfill which is leaching several known toxic organic chemicals into a small creek that flows into the James River below Richmond. There is a planned chemical monitoring effort to establish the magnitude of the problem.

Marshall Brook in **Acadia National Park** is being affected by toxic leachate from Worchester Landfill in the southern part of Mount Desert Island. The Park Service is cooperating with the EPA in evaluating the extent of chemical contamination and biological effects. Data from both agencies are being used to force the dump's closure and are specifying mitigation measures to render the leachate non-toxic.

Valley Creek in **Valley Forge National Historical Park**, is impacted by a polychlorinated biphenyl (PCB) spill upstream of the park. Fishing has been banned in Valley Creek by the State of Pennsylvania because of high concentrations of PCB's in fish. The NPS is planning work with the State of Pennsylvania and U.S. Geological Survey to fully assess the problem and develop mitigation procedures.

A potential problem exists in **Glen Canyon National Recreation Area**, where high levels of selenium are occurring in the flesh of some game fish. Lake Powell is believed to be a regional depositional sink concentrating naturally occurring heavy metals.

DDT and its metabolites are still being found in significant amounts in areas of southwest Texas in the vicinity of **Big Bend, Carlsbad Caverns, and Guadalupe Mountains national parks**. Several piecemeal investigations have yet to determine the source and whether new, illegal use is occurring.

A new Department of Interior-wide effort is underway to determine the extent of water quality degradation and toxic substances in irrigation return water. Several Park Service areas in the West may be peripherally involved.

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Terrestrial Effects of Air Pollution

Results from the first four years of the Air Quality Division's Biological Effects Program are summarized in *Park Science* (Summer 1985, p. 8-9). The main points: 1) The worst effects of air pollution on national park vegetation come from elevated levels of ozone. 2) Heavy metals, such as lead, have the next most serious effects. 3) The worst effects are found in parks, such as Indiana Dunes and Santa Monica Mountains, that are designated class II under the Clean Air Act. 4) Fumigation exposure studies indicate that selection is favoring genotypes tolerant of air pollution and sensitive ones are being removed from the existing populations. The Biological Effects Program excludes study of terrestrial and aquatic effects from acidic deposition, which fall under a program of the NPS Office of Natural Resources. Some major additional results of the Biological Effects Program up to March 1986 are summarized below.

Ozone Injury on Pine Plots, 1985

	% Trees injured	*% Injury/ tree*
Great Smoky Mountains NP	90	5
Acadia NP	89	4
Indiana Dunes NL	100	5
Cuyahoga Valley NRA	97	3
Sequoia NP	87	9
Yosemite NP	58	5
Saguaro NM	52	3
Rocky Mountain NP	0	0
Everglades NP	(03-like symptoms awaiting final diagnosis)	

(Eastern parks = *Pinus strobus* (white pine) and *Pinus elliottii* (slash pine); western parks = *Pinus ponderosa* (ponderosa pine) and *Pinus jeffreyi* (Jeffrey pine)

Mammoth Cave National Park

The results of an air pollution injury survey in the fall of 1985 have been analyzed and summarized. Ozone injury was found on most of 14 species examined, and was common on six: *Cercis canadensis* (redbud), *Fraxinus americana* (white ash), *Fraxinus pennsylvanica* (red ash), *Platanus occidentalis* (sycamore), *Liriodendron tulipifera* (tuliptree), and *Asclepias syriaca* (common milkweed). Percent of injured individuals ranged from 3 for *Acer negundo* (boxelder) and *Acer saccharinum* (silver maple) to 100 for common milkweed. Injury per plant was greatest on the common milkweed, followed by wild grape (*Vitis* sp.), the ashes, and redbud. Significant differences between sites demonstrated that trees on ridges and higher elevations were most likely to be injured. Injury was found throughout the park, indicating uniform ozone concentrations (probably greater than 0.06 ppm).

Isle Royale National Park

Elemental analyses of bryophytes collected as far back as 1900 show concentrations of sulfur as high as 6120 ppm, nearly three times higher than normal values found in pristine areas in northern Canada. These values are consistent with elevated sulfur levels found in lichens in the park. Possible sources include the pulp mills and a power plant in Thunder Bay, Ontario and long-distance transport.

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The SARRMC Spruce-Fir Ecosystem Assessment Program

High elevation spruce-fir forests are a key natural resource for the National Park Service. Great Smoky Mountains National Park (GRSM) has the highest visitation of any U.S. natural area park; and the high backbone of the Smokies is the most visited part of the Park. The dark evergreen spruce-fir forests, rugged mountain scenery, and cool mountain temperatures form the aesthetic background of the visitor experience. In the South, spruce-fir forests are scarce and found only as a series of isolated island-like areas on the highest ranges. Those high elevation islands are rich in rare plants and animals, including both northern and endemic species. These forests form the headwaters of two-thirds of the Park's major streams. By far the largest block of southern Appalachian spruce-fir is found within Great Smoky Mountains National Park. Logging of spruce from 1880 to 1930 affected many spruce-fir islands in the south. GRSM protected a large block of virgin forest of this type. This makes the current threats to this ecosystem type all the more alarming. In fact, the remnant old-growth spruce-fir forests of the southern Appalachians will be forever changed within the next several decades.

What are the threats? The first recognized threat to these forests was the exotic insect, balsam woolly adelgid (aphid). The adelgid poses a severe threat to the narrowly distributed southern Appalachian endemic, Fraser fir (*Abies fraseri*). The insect has been in GRSM for about 20 years, has spread throughout the full range of Fraser fir, and is causing heavy mortality. The second threat is atmospheric deposition of pollutants. Of course the two threats may—and probably do—interact in their effects on this ecosystem.

The Terrestrial Effects Program under the National Acid Precipitation Assessment Program (NAPAP) is organizing regional cooperatives to address effects of atmospheric deposition of acidity on forests. Because of the relatively sudden and heavy mortality experienced by red spruce over the last 5 years in the mountains of Vermont and New York, because of several reports of unexplained growth declines

Visibility impairment due to emissions from the Atlas Mineral Processing Plant, Moab, UT, Arches National Park, September 13, 1979, at 9:45 a.m. Such air pollution is not unusual, even in western national parks.

throughout the range of red spruce, and because of widespread decline of conifer forests in western Europe, spruce-fir forest was the first type to be addressed under this program.

In 1984, the Southern Appalachian Research/Resources Management Cooperative (SARRMC), a regional consortium of universities, federal agencies, and state agencies, received funding from the U.S. Forest Service to develop a prototype research program on southern Appalachian spruce-fir forests. This effort was later used as a model for the Spruce-Fir Research Cooperative (administered by the U.S. Forest Service in Broomhall, PA), which includes both the southern and northern spruce-fir effort. Late in 1984, Great Smoky Mountains National Park was chosen as one of three intensive research sites in the South, and Peter White and Chris Eagar of the Park's research staff were named co-leaders (with Shep Zedaker of VPI) of one of the central research projects (the establishment of permanent vegetation plots to serve as the focus of other research efforts).

The SARRMC spruce-fir ecosystem assessment program is a 4-year integrated and interdisciplinary study. There are eight core projects which will develop data on basic ecosystem parameters. These eight projects, with 15 principal investigators from eight institutions, involve studies of atmospheric deposition; aerial survey; soil and plant tissues chemistry; dendrochronology; modeling; mycorrhizae, pests, and pathogens; disturbance history; and vegetation structure, composition, and vigor. Beyond these eight core projects there are several hypothesis testing projects, including recently started projects on soil nitrogen transformations and on red spruce physiology (using field and laboratory experiments). Additional grants will be awarded in the coming years. Since the full program is only a year old, it is too early to state by what mechanism and to what degree pollutant exposure and deposition is affecting these forests. The studies have produced enough information to cause serious concern, and the SARRMC spruce-fir ecosystem assessment program has been designed to provide the answers needed.

Because of their biological value and presumed sensitivity to acid deposition, spruce-fir forests in the Smokies have attracted other research attention as well—some 21 studies are being done or have been recently completed in these high elevation forests (ranging from studies of lichens, rare plants, and avifauna to stream and soil solution chemistry). A particularly important project with regard to NAPAP goals is being funded by the Electric Power Research Institute and is being carried out by Oak Ridge National Laboratory in cooperation with the GRSM Science Division. This project is looking in depth at the ecosystem processes associated with the movement of deposition from atmosphere, through tree canopies, and into soils.

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Materials Effects of Air Pollution

Research is underway in four areas: 1) Deterioration rates of stone and bronze; 2) *in situ* monitoring of cultural resource degradation; 3) distribution of cultural properties; 4) protection and mitigation strategies. The bulk of the research began in 1983-84.

Deterioration rates of stone are being studied through 10-year field exposure tests at four sites, in cooperation with the Bureau of Mines and EPA, who are sponsoring tests of metals and paints, respectively. These sites are at Research Triangle Park, North Carolina; West End Branch Library, Washington, D.C.; Environmental Measurements Laboratory, Chester, New Jersey; and Huntington Wildlife Forest, Newcomb, New York. A fifth NPS site will be established at Steubenville, Ohio in FY1986. At each site slabs and briquettes of Vermont marble and Indiana limestone are being used for measurements of surface and water runoff chemistry, as well as surface recession and other changes. Stone deterioration data will be correlated with environmental data recorded at these sites by EPA. In the first year of testing, recessions near 15 micrometers were measured for skyward surfaces of briquettes. Results of the surface chemistry suggest that the direct effect of gaseous sulfur dioxide at skyward surfaces was much less than the effect of acid rainfall. Research on bronze deterioration is limited. A field study is underway of more than 100 bronze plaques from the same foundry and exposed in sites across the northern U.S. since the early 1960s. The amount of corrosion will be correlated with environmental data from nearby monitoring sites.

The NPS is also establishing a network of monitored cultural resources. Intensive monitoring is underway at Mesa Verde National Park, Independence National Historical Park, and, as of mid-1986, Gettsyburg National Military Park. As in the stone field exposure program, deterioration and environmental data are being collected and correlated. At Mesa Verde, two test walls built of native sandstone are being used, one fully exposed, one sheltered in the cliff. Field test kits for park managers have been developed for intermittent monitoring at additional sites.

A geographic inventory of cultural properties with respect to pollution regimes is also being conducted to help assess pollution effects. Estimates of the distribution of cultural resources by their size, material, and location are being prepared from existing documentation. Exposure histories will be estimated from historic emissions and estimated deposition levels.

Protection and mitigation strategies are being evaluated through laboratory and field testing of the long-term performance of stone and other masonry treatments, and through cost comparisons of methods for cleaning masonry structures and bronze statues. The costs will be compiled from actual project costs in northeastern states.

Dr. Steve Norton from the University of Maine prepares to section a sediment core taken from the bottom of a study lake, Rocky Mountain National Park. The sediments revealed no discernible trend toward increasing acidity over the past 150 years, but growing development in the southern Rocky Mountain region is likely to cause increased acidic deposition in the future.

PARK NOTES

This section highlights environmental quality problems or informational activities in selected parks.

Glacier National Park

Cabin Creek Mine is a proposed surface coal mine located 6 miles north of Glacier National Park on a tributary to the North Fork of the Flathead River in British Columbia, Canada. Based on evaluations of the NPS, the State of Montana, and EPA, it is believed that construction, operation, and post-mine reclamation of the Cabin Creek Mine represent a significant threat to the water quality and quantity of the North Fork of the Flathead River, the western boundary of Glacier National Park. Similarly, the mine represents a very real threat to the bull trout fishery in the Flathead River Basin, since 15 percent of the spawning habitat for bull trout in the entire basin is in the immediate vicinity of the mine.

Based on these concerns, a reference on the Cabin Creek Mine was submitted by the United States and Canada to the International Joint Commission (IJC) in February 1985. This reference called for the IJC to investigate the potential transboundary water impacts of the Cabin Creek Mine under the Boundary Waters Treaty of 1909. In order to assess these concerns, the IJC established the Flathead River International Study Board to investigate the potential impacts of the proposed Cabin Creek Mine on water quality and quantity in the Flathead River Basin and also to assess the effects of the mine on fisheries and water uses in the Basin. The NPS is represented on the study board and on a number of the technical committees which have been established to evaluate various transboundary water effects of the mine. In the course of the study, effects on the waters and fisheries of Glacier National Park will be evaluated and effects on Glacier's special designations (e.g., Biosphere Reserve and nominated World Heritage Site) will also be assessed. The present schedule calls for the study board to submit a report to the IJC by the end of December 1986.

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Sky Pond and Taylor Glacier, Rocky Mountain National Park. Sky is the uppermost lake in the Loch Vale Watershed, where NAPAP acid deposition studies are being conducted.

High-level Radioactive Waste Disposal

In accordance with the Nuclear Waste Policy Act, the Department of Energy (DOE) identified nine candidate sites, predominantly in the western United States, for the nation's first high-level radioactive waste repository. Two of the nine sites (Davis Canyon and Lavender Canyon) are immediately adjacent to Canyonlands National Park. Neither of these two sites are among the three selected by DOE for characterization (i.e., further in-depth field studies); however, either site could be selected for characterization later if none of the three originally selected meets the requirements. NPS reviewed the Draft Environmental Assessments for the Davis Canyon and Lavender Canyon sites and recommended that both be declared unsuitable as repository sites. Among other things, a major concern of NPS was the geologic instability of the area and the potential for contamination of surface and ground water in Canyonlands National Park and ultimately the Colorado River.

DOE has recently completed the regional screening for a second high-level radioactive waste repository in the northeastern, north central, and southeastern United States as called for in the Nuclear Waste Policy Act. Based on this screening, DOE has identified 20 preliminary candidate areas for a nuclear repository site. NPS has reviewed DOE's Draft Area Recommendation Report on these areas and has raised a number of concerns about four of these areas where a high-level nuclear repository might have hydrologic impacts on nearby NPS units (namely, Great Smoky Moun-

A view down White Oak Run (foreground), a Shenandoah NP acid deposition watershed study area in the South District. Research in Shenandoah indicates that one third of the Park's streams will become acidified in the next few decades.

tains National Park, Blue Ridge Parkway, Appalachian National Scenic Trail, and Saint Croix National Scenic Riverway). At this time, DOE plans to conduct area field studies in 12 of the 20 areas; a final decision as to which will be studied is expected in the fall of 1986.

Dan Kimball

Visual effects are also a concern at any proposed repository near a park unit. The repository would operate 24 hours each day with necessary outdoor lighting to perform the work and provide lighting for security at night. The NPS Air Quality Division conducted a study of night sky glow at the two Canyonland sites, using a mathematical model to predict effects (*Park Science*, Fall 1985). Conclusions were drawn that 1) the proposed repository, at either site, would probably cause a perceptible night glow and obscure the view of dim stars and the Milky Way in some portions of the sky from many locations within Canyonlands, and 2) some terrain features visible from Canyonlands would be illuminated directly by repository lighting and would be visible from adjacent parts of the park. The model presumably could be used at other locations if modified for local conditions.

Gateway National Recreation Area

Discharges from New York City, including chlorinated hydrocarbons, petroleum, heavy metals, leachate from sanitary landfills, and sewage treatment plant effluent, have seriously polluted Jamaica Bay, at the heart of this park unit. Two of the landfills used by the city are part of Gateway. Under a New York State court order against New York City, dumping was supposed to cease as of December 31, 1985, and it has, in fact, virtually stopped. The Park Service plans eventually to develop these landfills into recreation areas, but first they must be rendered safe. This is expected to cost hundreds of millions of dollars, and simply determining who will pay is likely to be a lengthy procedure.

Appalachian National Scenic Trail

Radioactivity has been detected at buildings and grounds of a research lab beside a lake near the Trail at Pauling, New York. It is suspected that radioactive material and other hazardous wastes have been dumped in the lake. The dam at "Nuclear Lake," as it has been dubbed, is in poor condition, presenting the possibility that dangerous materials will be released downstream if the sediments are disturbed. Investigation of the matter is now in the hands of the Nuclear Regulatory Commission.

Padre Island National Seashore

Currents of the Gulf of Mexico bring to Padre Island some 100 to 300 barrels of hazardous waste each year from freighters, oil and gas platforms and other sources. Some of these barrels contain material so toxic that a person could die within minutes if he or she took the lid off and smelled the contents. Not knowing the danger, people sometimes use such barrels for shelter or as a windbreak for campfires. Under a special agreement with EPA, the Park Service is using Superfund money to analyze and dispose of this hazardous material, but in FY1987 NPS will be required to fund this work itself.

An abandoned mine opening in the Big South Fork NRRA produces acid drainage that contaminates nearby streams. This is a widespread problem in the central Appalachians.

Sequoia-Kings Canyon National Parks

Evidence to date indicates that ozone is the air pollutant currently causing the greatest effects on biological resources in these parks, injuring ponderosa and Jeffrey pine and black oak. Injury to pines along the front range (western side) of Sequoia and Kings Canyon National Parks has doubled since 1980. Eighty-seven percent of the pines in study plots in Sequoia in 1985 were injured. The San Joaquin Valley, immediately west of the parks, is a major source of ozone.

Great Smoky Mountains National Park

An exhibit on air pollution sources and its effects in the Park is in preparation and should be on display at Newfound Gap sometime this summer. Consisting of one large panel flanked by two smaller ones, it will explain the causes of the frequent haze that obscures views; describe research and monitoring in the Park and the effects of air pollution on vegetation, such as ozone damage to white pine and retarded growth of red spruce; and present general information on types of pollutants, their sources, and the prevailing directions from which pollutant-bearing air masses reach the Smokies. The concepts and information for the display were developed by the park scientists and interpretive staff and the NPS Air Quality Division. The Harpers Ferry exhibits unit is working with a contractor who is producing the finished product.

This project is seen as a prototype that can be adapted for use in other parks as well. Great Smokies is one of at least 40 park units that now have some interpretation of air quality issues.

Delaware Water Gap National Recreation Area

This park has streams that are sensitive to acid deposition, acidified lakes, slow weathering parent material, and vulnerable organisms including trout and salamanders. In February 1985 a workshop was held here to bring together scientists who are investigating acidic deposition effects in or near the Recreation Area. The workshop was eminently successful in fostering communication among regional scientists and with the park staff, and in developing management recommendations for the park. See Recent Publications for citation of the workshop report.

RECENT PUBLICATIONS

This section lists selected publications on environmental quality that resulted from studies in the National Park System or that relate more generally to pollution issues.

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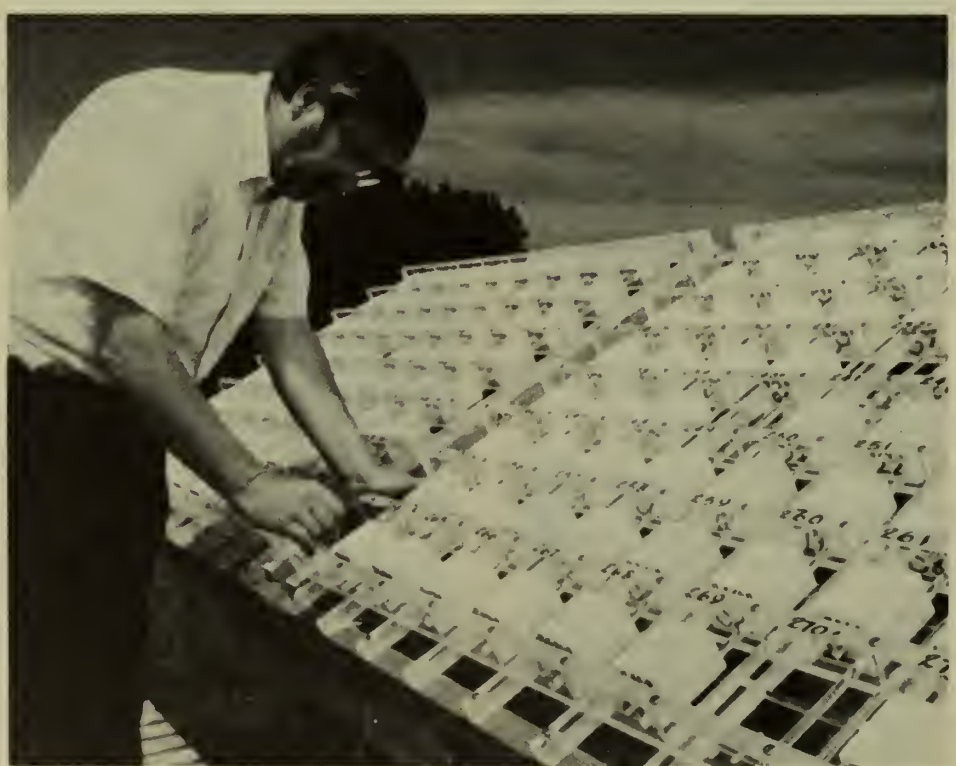

A technician examines a field exposure test rack with Vermont marble (foreground) and Indiana limestone (background) at Research Triangle Park, NC.

Book Reviews

Charles P. Stone and J. Michael Scott, eds. 1985. Hawai'i's Terrestrial Ecosystems: Preservation and Management. Cooperative National Park Resources Study Unit, University of Hawaii, Honolulu. xxvii, 584 p.

Preservation of the Hawaiian flora and fauna presents problems in a different order of magnitude from those ordinarily found in other areas. The Hawaiian biota is considerably more fragile than those of mainland areas, because Hawaiian plants and animals have evolved in ecologically lush conditions free from predators, pests, and competitors. Suddenly, with the advent of man, especially after European exploration, the predators, pests, and competitors have flooded into the islands, often in unexpected ways. Ornamental plants have escaped from gardens into the wild, as have trees introduced in an effort to grow commercially valuable timber.

Until relatively recently, mainland ecological concepts were assumed by most involved to be applicable to the Islands, but they are not. Once introduced, the newcomers are not displaced by the natives. The underlay of disturbance by tenacious herbivores – goats, pigs, and sheep – accelerates the entry of the introduced plants and animals.

Thus, readers of this volume will find little of encouragement, and much implicit distress in the management problems presented. The book's authors are to be congratulated for their thorough documentation of which organisms are in danger, which introduced species are doing what, and which conservation measures are yielding what results. This book contains, to my knowledge, the first such documentation for the biota as a whole. Whatever reservations readers might have about coverage in this book will surely be insignificant compared to the achievement represented here. Levels of information and documentation are excellent, and the contributions are thoughtful. Because the scholarship is so good throughout, I feel that singling out particular chapters for congratulation would be invidious.

The Hawaiian management problem features some unusual paradoxes, most of which are realized by the authors. For example, biological control organisms are highly desirable, but their use is irreversible and they may spread in unpredictable ways (Howarth). Research is advocated by several authors, but funds for such unglamorous work are not readily available; also, there is more than a passing chance that research will not yield much more than a timetable for disappearance of some species. A research effort may merely document disappearance rather than counteract it; the disappearance may proceed so rapidly that the luxury of research is not a viable option.

Exclosures to protect plants from goats and other herbivores (Loops and Scowcroft) have yielded good results in some cases. In areas with few species or with higher degrees of degradation, results are naturally not noteworthy, and thus that program unfortunately may not inspire strong support. Should more exclosures be devised? Undoubtedly, but in what areas, and with what funds are troubling questions. Breeding of the Hawaiian goose in pens was a success at the captive maintenance stage, but release into the wild without constant addition of new individuals every year does not succeed, for the goose can no longer maintain itself in areas in which it once thrived (Lamoureux).

Authors are agreed that we must stop further disturbance of the ecology, if species are not to continue vanishing, but multiplicity of authorities responsible for management and the delicacy of politics offer problems (Stone and Scott). Moreover, there are no guarantees that if all measures were taken, any given area could be restored. Zoo and botanic garden populations of some species might be our best hope for the future, although that kind of conservation will not help some groups of organisms, such as insects. Very likely we will have to consider some areas as irretrievably lost to exotic flora and fauna.

In sum, this is a fine book, which deserves careful reading by all seriously interested in management. Hawai'i's management problems are severe, but the rest of the world may not be much safer, and we ignore the Hawaiian experience at our peril.

Dr. Sherwin Carlquist
Professor of Botany, Claremont Graduate School, Claremont, CA.

Cahn, Albright Collaborate On NPS History

THE BIRTH OF THE NATIONAL PARK SERVICE: The Founding Years, 1913-1933, by Horace Albright as told to Robert Cahn. 1985. Howe Bros., an Institute of the American West book. 340 p. $19.95, hardcover; $10.95 softcover.

From its cover photo (Yellowstone falls) and its title page (the three Tetons) through the liberally illustrated text (historical photos and line drawings) to the back cover shot of Bob Cahn and Horace Albright in 1981, this is a personal memoir worthy of any library. If the collector is intent on achieving a complete picture of the National Park System and Service, this will be one of many volumes he will need; for the truth of the matter is that both Service and System have never been defined in all their evolving complexities.

Few people, however, can present a longer continuous thread in the emerging tapestry than Horace Albright, second director of the Service at whose birth he was, together with Stephen Mather, a midhusband (if not exactly mid-wife). The 96-year-old Albright not only retains all his sparkling marbles, he uses them to create a scintillating pattern of "how it all came to be" for the talented pen of his own Boswell – Bob Cahn. The result is a fascinating facet of the complex national jewel that is the combined National Park System and Service.

A colorful review, by columnist Hugh Sidey, appeared in the Dec. 23, 1985 issue of *Time Magazine.*

Howe Brothers address is P.O. Box 6394, Salt Lake City, Utah 84106.

THE STATE OF THE WORLD'S PARKS

Gary Machlis and David Tichnell undertook a challenging task – a survey of the parks of the world – in a quixotic effort to answer two questions: "What are the threats to national parks around the world?" and, "What can be done about them?" The authors sought answers to these questions through a systematic, interdisciplinary examination of a representative sample of the world's parks obtained via a carefully constructed, mailed questionnaire.

The results of this effort appear in their book, *The State of the World's Parks – An International Assessment for Resource Management, Policy, and Research* (Westview Press, Boulder, Colorado, 131 pp., 1985). The book's first three chapters set the stage for its last two chapters by presenting the assumptions on which the project was based, establishing that an intimate relationship exists between the human culture and the biophysical environment that together make up a park, and defining the biological and social variables that influenced the design of their questionnaire and the direction of their analytical approach. The last two chapters describe the methods used to gather and analyze the data, present the data and their analysis, and suggest the conclusions and recommendations that can be drawn from the analysis. The appendices provide information on the research methodology and the characterization of the parks included in the sample.

The strength of the book lies in what it says about the background of the project: the orderly development of assumptions, the analytical discussion of social and biophysical linkages, the theoretical underpinnings to the determination of key variables, and the thought and testing that went into developing the cross-cultural, multi-lingual written survey instrument. The assumptions were that: 1) a significant portion of human social behavior has a biological basis, 2) humans have special traits that permit wide behavioral variation, 3) people are ecologically interdependent with the natural world, 4) understanding this interdependency benefits from using a systems approach to analysis, and 5) the concept of "threat" includes "stress," "detrimental impact," and "valued component," a combination of biological and cultural terms that support adoption of a working definition of threat as: an activity of either human or natural origin that causes significant damage to park resources, or is in serious conflict with the objectives of park administration and management.

The social and biophysical linkages included: 1) interrelationship between parks and subsistence needs of indigenous peoples, 2) influences of park-oriented tourism on local cultural and economic patterns, 3) conflicting management purposes of preserving specific habitats and species compared to permitting ecological change to proceed unimpeded, 4) controversiality of some needed management techniques, 5) ecologically inadequate boundaries, 6) recurrent conflicts between preservation and use of parks, and 7) the role of indigenous practices in maintaining desired ecological conditions of parks. The variables adopted as key for this study of threats to the world's parks were: biome type, park size, stage of economic development of the parent country, and presence/absence of specialized management programs (world heritage site, biosphere reserve).

The results of the survey are the disappointing part of the book – at least, at first blush. One hundred thirty five parks were sent questionnaires. One hundred parks replied, with 98 regularly represented in the data being presented. The responses represent 13 biome types, 4 size classes, 7 biophysical systems comprising 48 subsystems identified by the authors plus another 60 subsystems identified by the respondents, 3 stages of economic development,

and 2 alternatives for management emphasis. The data are spread throughout this multidimensional matrix; are of a nonquantitative, YES/NO nature; do not lend themselves readily to grouping and statistical analysis; and must be presented primarily as percentages of the total, which becomes confusing since the subject which is totaled varies from table to table and the citations of percentages in the text do not always make crystal clear which subject is the reference subject. Where grouping is possible, we see only 4 (and in some cases only 2) of the 13 biome types and only 2 of the 4 size classes represented. With such an apparent mish-mash, you may wonder, why bother with the rest of the book?

Several reasons. First, this work is as statistically valid a sample of the world as the authors could achieve. Second, the authors made a great effort to minimize cultural biases in developing the questionnaire and translating it into other languages. Third, the confusing welter of threats and the lack of much commonality among the threats revealed by the survey tell us a great deal about our natural world – especially that humans are affecting every corner of it, that the impacts of these effects are very site specific, and that the types of threats being experienced vary with the stage of economic development. Fourth, the conclusions and recommendations presented in Chapter 5 offer kernels of thought that are applicable to the problems that all of us face in our day to day work.

In my view, the authors have met their goal – they have identified threats that face the world's parks and they have offered ideas of what can be done about these threats. For example, better park protection may be achievable in many places through development of a "conservation" park within a total regional land use program rather than through development of a "preservation" park that operates in ignorance of how the park neighbors are using the adjacent lands.

Another example is a suggestion to develop a worldwide strategy to combat poaching.

A third suggestion is that, because it is difficult to administer national policies while at the same time solving local problems, national policies should be structured to combine strong objectives with maximum flexibility in meeting the objectives.

Fourth, the authors urge that a continuing program of research be conducted to support nations in dealing with threats to their parks, and that this research be structured to overcome existing fragmentation created by the "orthodoxies of academic organization" and to become an interdisciplinary whole that focuses on "preservation science" (p. 93).

Fifth, parks are in fact multiple-use areas that must be managed in integration with their regional socioeconomic systems so that measurable benefits flow from park to region (p. 97).

We, the readers, can apply the ideas developed here in our every day activities. We can redouble our efforts to see threats for what they are, to conduct needed research with appropriate scientific rigor, and to apply the findings of that research to solving those threats that are within our span of control.

Above all, we can take the reminder to heart that parks are social institutions and that, although we can take firm stands for park needs, the parks do not exist in vacuums and, therefore, the meeting of park needs must be achieved in cooperation with the meeting of the needs of both park neighbors and park supporters.

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2 Reviews
NPS Legislation Reinterpreted

In the Fall, 1984, issue (Vol. 15, No. 1, pp. 41-66) of *Environmental Law* (Northwestern School of Law of Lewis and Clark College), there appeared an article entitled "A Reinterpretation of National Park Legislation" by John Lemons, Ph.D, Associate Professor of Environmental Studies at Sweet Briar College, and Dean Stout, J.D.

The two authors delve into legislative history and court opinions in an attempt to shed light on what most employees and followers of the National Park Service have often read about and more often have discussed: the dilemma over the competing goals of park use versus park preservation enunciated in the 1916 Organic Act. Their conclusion is that "the most basic fiduciary duties of the NPS are to reduce development and promote preservation of resources." As they interpret the Organic Act, these basic duties have three basic objectives which are:

- to conserve the scenic, natural, historic and biotic values of parks;
- to promote enjoyment of park resources by the public; and
- to provide for public enjoyment of park resources so that these resources are left unimpaired for future generations.

The article deals briefly with the litany of internal threats caused by overuse and overdevelopment facing the natural, cultural and recreational resources of the National Park System today. The State of the Parks Report, Cahn's "Will Success Spoil the National Parks?" and other documents describing internal park threats are briefly mentioned to set the scene. The authors also list various park developments such as luxury hotels, swimming pools, tennis courts, bars, apparel stores, etc., which the authors obviously include under the rubric of "park threats."

Next, the authors review the traditional interpretation of the preservation versus use dilemma. Because government agencies attempt to take a middle-of-the-road approach, the authors claim it is not at all surprising that the NPS has avoided limiting access to parks whenever possible. They review the period in NPS history when tourism was promoted to gain political support for parks, and they view certain NPS launched development programs as methods to make parks more accessible and to increase visitor facilities.

In addition, the authors feel that influential members of the conservation community did not foster the preservation mandate in their writings. They specifically cite Joseph Sax who, in his *America's National Parks,* maintains that the statutes are of very little help in balancing preservation and use, and A. Runte who, in his *National Parks: The American Experience* indicates that because the legislation does not adequately define the purpose of parks, it cannot be used to resolve conflicts.

From these introductory sections, the authors turn to the Organic Act, its legislative history and court opinions to develop their own interpretation of the Park Service mandate. They provide an interpretation that strongly supports the preservation of park resources. In Lemons and Stout's view, Congressional intent does permit the accommodation of visitors, but with two significant conditions:

(1) Visitor enjoyment must be enjoyment of park resources and not enjoyment of luxury hotels, tennis, golf or other non-resource-related activities; and (2) visitation must not impair park resources. For them, visitor use and enjoyment is legitimate only when it is limited to those activities which do not cause impairment. Their interpretation alleges that resource impairment would violate the fundamental purpose of parks, i.e., strict and uncompromising preservation.

The article is well-documented and well-written. The authors obviously have researched their topic well, and those interested in the future of the National Park System would do well to give it a thorough reading. The authors state that the article "is intended to stimulate discussion and clarification of park legislation." It is sure to do just that.

Thomas W. Lucke, Chief
NPS Water Resources Division

The Intent of Congress on Preservation and Use

By Glen F. Cole

The policy of Congress for the management and use of national parks is stated in Section 1 of the 1916 Organic Act. Here Congress directed:

> The Service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

This directive to promote and regulate the use of national parks in a manner that both preserves and provides for the enjoyment of their natural scenery and biota has always been clear to me because it establishes that parks have some measurable capacity to accommodate use. Here, different kinds and amounts of use can either be below or at levels that cause impaired (i.e. human modified) conditions. In contrast, others have considered Section 1 to be a conflicting legislative mandate. As near as I can assess, such interpretations result from philosophical views that preservation and any presence of humans are contradictions, from failures to distinguish between a park's developed areas and natural zones, or from assumptions that Congress did not intend that the specific language of Section 1 be strictly followed.

In a 1984 article which is titled "A Reinterpretation of National Park Legislation" (in *Environmental Law* Vol. 15:1, p. 41-66) John Lemons and Dean Stout review congressional law as it relates to the "preservation versus use dilemma" and the management policies of the National Park Service. They conclude that past interpretations of park law ignore the express language of Section 1 of the Organic Act, and written policy fails to clarify the intent and meaning of congressional laws. They point out that the laws enacted by Congress, rather than the desires of particular users, should be taken by the National Park Service as an expression of both the national interest and public desires. Their final recommendation is that a Congressional or public policy task force

Acid Deposition: Long-term Trends. Committee on Monitoring and Assessment of Trends in Acid Deposition, National Research Council, National Academy of Science, National Academy Press, Washington, D.C. 1986. 506pp.

This is the fifth published study undertaken by the National Academy of Science (NAS) concerning deposition of atmospheric chemical pollutants. The report's objective is to analyze present and historical data to see whether emissions, acid anion deposition, and ecological effects might be linked over the period of industrialization. Should they be linked this could reveal possible cause-effect relationships.

The report has nine chapters dealing with emissions of sulfur and nitrogen oxides; trends in sulfate and visibility (visibility is linked to sulfate levels); precipitation chemistry; and the effects of atmospheric contaminants on forests, lakes and streams. Sections of the text are not light reading. Knowledge of the topic is desirable to comprehend much of the text.

The NAS report provides a good, reasonably current review of the research, hypotheses, and attempts to link cause to effects. The topics addressed were selected based upon the availability of published or original region-wide spatial or temporal data.

Statistical analyses of these data reveal a strong relationship among emission densities of sulfur dioxide, sulfate aerosol concentrations, the range of visibility, wet precipitation sulfate concentrations, and sulfate fluxes in USGS Bench-Mark streams (Smith et. al. 1982, Smith and Alexander 1983). Since reliable precipitation data are generally absent prior to 1978, these relationships are especially important in estimating what historical deposition of acid precipitation and its associates might have been. These relationships are used to link emissions in the eastern portions of the US to probable deposition rates over time.

For example from limited historical visibility data and gradients of sulfate in lake sediments the study concludes that high levels of acid precursors have been emitted over Eastern North America from the turn of the century. Since 1920 these emissions have remained about the same. From about 1970 major differences in emissions have existed among regions of the eastern US especially north and south. Based upon historical visibility and especially stream chemistry data (USGS Hydrologic Benchmark Stations and sites at the Hubbard Brook Experimental Forest) it appears that for the last 15 years the southeastern US has incurred the highest rates of increase in factors related to acid precipitation with the midwest region following.

Historical stream water chemistry for these regions indicate that sulfate flux effects change in stream alkalinity and base cation concentrations, particularly where soils are acid and streams have low alkalinity. However, historical lake water chemistry data for the midwest and northeast are not nearly as conclusive. Some suggest declines in alkalinity while others show increases. Also in many cases of alkalinity decline the rate is so rapid that factors other than acid precipitation are probably involved. An exception to this, of course, is the well documented case of chemical and biological change strongly linked to acid precipitation for 10 Adirondack lakes.

The report is scientifically valuable since it analyzes much data for the first time. However, it accomplishes little in carrying out its primary objective of establishing the cause-effect relationships between acid precipitation and aquatic or terrestrial effects. For example "there is no indication now that acidic deposition is an important factor in the red spruce decline." (p. 25). It is unable to even achieve this for regional lake effects, the arena of perhaps the most intense recent study within the National Acid Precipitation Assessment Program (NAPAP).

To its credit the study devotes appropriate attention to the complexity of this issue, in particular the constraints added by a lack of historical monitoring and research data, the inability to analyze much historical data because they were obtained using inconsistent or poorly documented procedures, and the basic lack of knowledge on the structure and function of ecosystems.

This NAS report, while addressing the issue of acid precipitation, contains many examples and statements of explicit value in the assessment of research and resource management strategy for a bureau such as the NPS. Some of the major ones follow.

First, acid precipitation has been an intensively studied issue in recent years. Despite this widespread but short-term effort, some of the most valuable data for assessing trends in past and present deposition and its probable effects have been long-term baseline data for which collection began long before acid precipitation was an issue. These data, mainly surface water chemistry, benthic lake cores and air visibility, were comprehensive, were routinely collected using consistent procedures with quality assurance, and the procedures were documented. These are minimal *a priori* requirements for data to be useful in future evaluations of environmental effects, especially in adversarial situations.

Second, a major factor in finding clear cause-effect relationships, as for example acid deposition and lake or soil acidification, is the need for *long-term* research and monitoring. In many instances what will be required is detection of statistically significant trends in concentrations of chemical compounds which also occur naturally with considerable year-to-year variation.

Third, much historical and even quite recent data have had to be discarded in such evaluations because they were not collected in a consistent manner using documented procedures which included quality assurance.

Fourth, the ecological effects of acid precipitation are inherently complex, much more so than most initially thought. The effects are often subtle, affecting processes within ecosystems, ecosystems whose structure and function are still poorly understood. This will probably be found the case in many future anthropic threats.

It is evident that these are minimal components of a strategy the NPS must employ nationally if it is to carry out its mandate of park preservation.

Smith, R.A., and R.B. Alexander. 1983. Evidence for acid precipitation induced trends in stream chemistry at Hydrologic Bench-Mark Stations. Circ. 910 US Geological Survey. 12pp.

Smith, R.A., R.M. Hirsch, and J.R. Slack. 1982. A study of trends in total phosphorus measurements at NASQAN stations. US Geological Survey Water Supply Paper 2190.

Robert Stottlemyer
Michigan Technological University

Chase, Alston, 1986. Playing God in Yellowstone: The destruction of America's first national park. Atlantic Monthly Press. 446p. $24.95.

This book in the short time since its publication has caused considerable controversy and is sure to cause much more. It is for the most part, a very readable book, however it is written in a style that is confrontational and is laden with value judgments. Even the chapter headings, e.g., Killing Animals to Save Them, An Environmental Ideal and the Biology of Desperation, Gumshoes and Posy Pickers, are a sarcastic characterization of a given situation.

The book is divided into three main parts. The first deals with The Range and The Wildlife and discusses the wildlife management problems associated with Yellowstone. Emphasized are the historic control of predators and whether or not the wolf continues to exist in the park, the various attempts to manage the elk populations, and the arguments over grizzly management. Of the two chapters on bears, one is largely a revision of material that appeared in *Atlantic Monthly* in 1983, the second a duplicate of the article that appeared in a recent edition of *Outside Magazine*. The latter has been extensively critiqued by the Yellowstone Park staff.

The next section entitled The Rangers deals with the power structure and hierarchy of the NPS and the role politics and management play in decision making. The focus of one chapter is on the repeated attempts to establish the Grant Village complex at Yellowstone. The final section is a philosophical treatment entitled The Environmentalists. It includes such "strange chapters" as The Hubris Commandos and The California Cosmologists.

I found the final section rambling and disconnected from the rest of the book. I am not sure I understood it all or that I cared to. I felt it added little to the book. I think the author is on safest ground and most insightful when dealing with the problems of the NPS science program as a whole, as in The Rangers. I feel that many scientists and resource managers will concur with his characterizations of the roles that rangers, scientists, and interpreters have in the NPS.

Chase, as am I, is a staunch admirer of George Wright, and reflects on the potential influence this individual might have had if he had survived. Whether

Continued on page 16

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be created to review NPS compliance with existing legislation.

As an alternative or in addition to any outside reviews, it would seem desirable for the NPS to routinely monitor its own compliance with statutory law. This could take the form of adding a "critical element" to the performance standards of persons whose decisions or actions could be inconsistent with such laws. As an example, the written standard that has been used in Voyageurs National Park since 1983 is that job performance is in accord with a park's enabling legislation and the amended and supplemented 1916 Act. Here, job performance that either enhanced, did not impair, or impaired the park's natural or cultural resources, or appropriate public enjoyment of these, is rated on a scale of one to five by distinguishing higher and lesser levels of enhancement or impairment. This use of performance standards to monitor compliance with park law contributed to an increased awareness of the congressionally mandated purpose of the park and the statutory constraints that are placed on promoting and providing for public use.

Continued from page 15

the opinions attributed to Wright are accurate, is however, hard to judge. He writes that Wright was "appalled" to discover that the government made no attempt to administer parks along scientific lines, and that he made another "discovery" that control of predators was common in parks. The point that the NPS secretly controlled predators in the 1930s is made repeatedly, when in fact that policy was widely acknowledged and its efficacy was being publicly debated e.g., National Parks Association (1924). In fact Fauna No. 1 (Wright et al. 1933 pp. 48) argued for continued coyote control in Yellowstone.

Throughout the discussion of The Range and Wildlife chapters, there seems to be only one way of looking at things, only one truth. This may be one of the book's greatest weaknesses. Chase strongly argues the premise that predators are important in controlling ungulate populations. Clearly this is a concept that is yet to be resolved. However, rather than treat it objectively, he vilifies Yellowstone scientists and others for ignoring this principle. Any studies which showed that some populations might be resource limited, (he particularly picks on Caughley [1970]) are referred to as "tantalizingly incomplete." Chase further implies that the adoptions of park policies have often been timed to coincide with political rather than biological necessity.

He accuses Yellowstone researchers of misinterpreting the writings of others to enhance their own objectives, such as in speculating on historic elk populations in the park. In fact he is guilty of the same. For example he implies that Houston (1982) maintained that elk had lived specifically on the Yellowstone plateau in numbers for millennia, when in fact Houston states: "Archaelogical data show that elk have been present in the Yellowstone *area* for millennia" and that "Elk could not have occupied most of the Yellowstone area until about 12,000 years Bp . . ." (Houston 1982, pp. 23, 10).

Although many inaccuracies occur in the book, e.g., referring to George Hartzog as Secretary of Interior and implying that no individuals in the Rocky Mountain Region are under Research-Grade Evaluation, it is not my intent to dwell on specifics. I think Chase has done a good job surveying the literature pertinent to the subject. I don't think his scholarship is as good in his personal interviews. I got the distinct impression that he only included comments from those people whose opinions fit his own preconceptions and that he did not necessarily follow up on the validity of such comments even when they were controversial. This problem is compounded by the fact that some of the most damning comments come from interviewees whose identities are withheld. I also had the impression that he has had conflicts with certain personalities at Yellowstone and his association with these individuals has unfortunately colored his perceptions of all national parks.

In the final analysis I enjoyed immensely reading the book. Even with its many problems, I came away feeling that he had in many instances clearly identified some nagging problems in the NPS science program. Some of these problems are obvious, others are such that they often take an outsider to see. Some beg an answer; others are solvable. For these reasons, even if it makes you mad, I recommend reading it.

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More Fuel for the Fragmentation Fire: A Reply to Bratton and White

By James F. Quinn and Charles van Riper III

We welcome the comments of Susan Bratton (*Park Science,* Winter, 1986) and Peter White (Spring issue) on our essay concerning island biogeography theory and its use in the strategy of nature reserve acquisition. We would like to amplify some of their points, and observe that the scientific and policy questions involved are rather different.

The philosopher Karl Popper (1972) has labelled the scientific process as "conjecture and refutation". The conjecture that has been offered to conservation biologists is that a given amount of habitat (in this case, nature reserves) subdivided into a large number of small units ("fragmented") will contain fewer species (Diamond 1975, Sullivan and Shaffer 1975) and will have a greater probability of extinction for susceptible species (Shaffer 1981, Wilcox and Murphy 1985), than will the same total area concentrated into one or a few large units. It is this conjectured principle of nature that we have set out to test.

Although the regular species-area curves observed on islands stimulated the conjecture, it does not actually follow from the resulting theory, as Simberloff and Abele (1982) have pointed out and we illustrated by our hypothetical archipelagos. The general effect of fragmentation (many small units) on diversity is therefore an empirical question.

As far as we know, the experiments that we reported are the first *experimental* tests of the effects of fragmentation on diversity. As Bratton observes, their applicability to parks can be debated on the basis of their size and the choice of species. A variety of "natural experiments," using islands or stands of natural vegetation, is now in the literature (reviewed by McLellan et al. 1986), with species and spatial scales of greater relevance to conservation decisions, but poorer control of other confounding variables. Few tests have been conducted using National Parks or other conservation areas. Bratton, Miller and White's work in the East, and ours in the Western Region, are attempting to fill this gap.

Bratton and White express cautions on interpretation of our work. Most we offered in different language in our essay. However, our main objective was to test the proposed ecological principles involved, not to make predictions for actual management decisions. Nevertheless, it should be remembered that:

1) **Choice of scale and species**

Our experiments are model systems, conducted on a small scale and using species of limited direct conservation interest. The response of conservation targets to the fragmentation of natural landscapes obviously could be quite different from that of the "weedy" species common in our experiments. The terrestrial experiment mimics the process of reserve formation in that "parks" were carved out of a continuous landscape, but the marine experiment involves colonization of new areas.

2) **Habitat diversity**

That a collection of small areas generally appears to contain more species that a comparable large area may have a variety of causes, notably habitat diversity, having little to do with reserve or island size alone.

3) **Extinction of conservation targets**

We have analysed the total number of species rather than particular conservation targets, and our results may not hold for the smaller number of species threatened with extinction. In particular, White raises the conjecture that there may be some rather large (circa 500) "minimum viable population size" for large rare animals, below which populations may be rapidly lost from habitat "fragments." It is also possible that inbreeding and loss of genetic diversity could cause long term declines.

4) **"Faunal collapse"**

The results observed in our studies and others like them may not reflect long term diversity patterns because species are more likely to go extinct in "fragmented" habitats during "faunal collapse."

All these processes occur, whether or not they are relevant to the scientific question we set out to address. However, several deserve additional comment.

The use of experimental models is common in science – witness *Drosophila, E. coli,* and white laboratory rats. They may be used to reject universal theories, but can not prove generalizations. That is the situation with our study. Experiments with varying National Park system designs and endangered species are infeasible (and probably immoral). Even the ambitious and admirable World Wildlife Fund experiments in Amazonia (Lovejoy et al., 1984) cannot directly answer the question of the least harmful way to clear the forest – the largest experimental plots are too small and the smallest far too poorly replicated. In any case, the results do not necessarily apply to other ecosystems any more than do other models.

So we are left with inadequate information as the only available substitute for no information. We believe simple experiments can be informative, though never definitive, in outlining processes important on the larger scales inaccessible to experimentation. Diversity appears to be correlated with *increased* fragmentation on larger scales also. The challenge is clearly to evaluate the mechanistic effects of scale and taxon that Bratton and White have raised.

The appropriate choice of scale for our experiments is debatable. If grasses and leafhoppers are reasonable models for trees and birds in parks (which they may or may not be), the numbers of individuals, and accessibility of neighboring "parks" is probably not that different from those involved in many real park populations. Conjectures in the literature about fragmentation effects are notably vague about the scale involved, so experimentation on any relevant scale provides at least a partial test.

The ability of collections of small areas to harbor more species than fewer larger areas could have any number of causes beyond area or perimeter effects *per se.* One raised by both Bratton and White is that

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Wright, G., J. Dixon, and B. Thompson. 1933. A preliminary survey of faunal relations in national parks. NPS Fauna Series. 1. Washington, D.C.

a collection of dispersed small areas could incorporate more kinds of habitat than would fewer larger areas. This is clearly an important part of the explanation for the richer terrestrial large mammal fauna in the combination of Big Bend, Redwood and North Cascades than in the larger area of Yellowstone. We raised the example specifically to illustrate that real park systems in practice do effectively conserve important species in consciously dispersed areas. In fact, we think the very nonrandom placement of small parks and reserves is an important reason to reject the island analogy that has been used to dismiss the effectiveness of numerous small conservation areas.

In other cases, the greater species diversity of more fragmented habitats must have some explanation other than habitat diversity. Small oceanic islands have fewer habitats than large islands – they generally lack montane areas, lakes, rivers, etc. – yet in combination they appear virtually always to harbor more species (Quinn and Harrison, unpublished manuscript). The habitats in our experiments are as homogeneous as can be expected in a natural setting, yet they have many more species in the more fragmented treatments.

White notes that small reserves are more subject to losses on the perimeters, and provides several excellent examples. Collections of small reserves are also more likely to be encountered and settled by migrants, and may provide corridors for movement or invasion of new species. The consequences of perimeter effects, corridors, and buffer zones certainly need more attention.

The effects of fragmentation on the viability and population genetics of threatened populations are more problematical – one reason we addressed only overall diversity in our article. Reserves designed for particular species must be large enough to incorporate the range of movement and resources needed to maintain at least a small number of individuals. The fact that for some species the area involved can be enormous speaks to the need for some very large parks in the system. In more general terms, however, the relationship between reserve system fragmentation and population "viability" is not obvious.

Engineers know it is often less expensive to protect against system failure by making redundant copies of failure-prone subsystems than it is to improve the reliability of single units. The mean time to failure is often proportional to the logarithm of the number of redundant backups, and the probability of short term failure may decrease by factors of millions. If global extinction of a species is viewed as a failure of the conservation system, redundancy, in the form of multiple reserves, may decrease the probability of failure more dramatically than would comparable enlargements of a single reserve area. An example: when the extinction mechanism is an epidemic, isolated populations are likely not to become infected, and to be available to restart affected populations, as demonstrated by Carrick (1963). Conversely, of course, a sufficient increase in failure probability of each subsystem may increase the overall rate of failure in the whole system. Mathematical models can be constructed in which fragmentation either increases or decreases the persistence time of species (Wright and Hubbell 1983, Quinn and Hastings, unpublished manuscript.) Our experiments and the empirical evidence that we have found to date are inconclusive.

The relationship between extinction rate and population size is difficult to document. We know of no documentation of an abrupt threshold "minimum viable population size" beyond the obvious one of a single mating pair. California elephant seals, Laysan teals, and rhinoceroses in South African parks and Kenyan game farms would appear to provide counterexamples. The relationship between the loss of genetic information and reserve system fragmentation is equally problematical. As the populations in individual parks become smaller, local inbreeding and the loss of alleles through genetic drift become more rapid. On the other hand, if there are multiple subpopulations, different variants are likely to be fixed by local adaptation or drift in different places, and the genetic variation throughout the species may be better maintained.

White's final caution about the effects of "faunal collapse," due to the anticipated slow extinction of species from recently isolated parks, is certainly important, but difficult to evaluate. Even on the land bridge islands formed by post-Pleistocene sea level changes, in which faunal collapse is best studied, the estimates of faunal change (Diamond, 1974) come from present distributions, and are subject to many sources of error (see Lynch and Johnson, 1974). As White notes, the "collapse" is thought to have taken many thousands of years, suggesting that present patterns in new parks and reserves can not be used to investigate the process (Soule et al. 1979). The best we can do is to investigate the post-"collapse" biotas of island archipelagos. All of those we have examined have more species (and more endemics) on collections of small islands than on single large ones. It is of course possible to dismiss the island data as irrelevant because of the specialized biology of island species. Doing so, however, makes the whole matter untestable in our lifetimes, and not worthy of scientific debate (Simberloff and Gotelli, 1984).

Policy implications

The effects of park size and number on diversity and extinction rates obviously are relevant to conservation strategies. Equally obviously, they are not the sole, or necessarily even a principal determinant, of the best management approach, for a variety of reasons admirably summarized by White. We believe that a growing weight of evidence rejects the conventional wisdom that diversity considerations *per se* require establishment of very large parks (see also Simberloff and Gotelli, 1984). It does not follow, of course, that many small parks are the best solution – our view is similar to White and Bratton's – that a mixed strategy of some kind will probably be most effective.

While we agree with White that the best conservation strategy would be to have both more and larger parks and reserves, political and economic realities are likely to dictate more stringent choices. In general, the tradeoff is between marginal increases in size of individual reserves, which decreases their individual susceptibility to biological failures of various kinds, and marginal increases in numbers of reserves, which spreads the risk of total failure over a larger number of survivable units. The risks of fire, contamination, or groundwater catastrophes cited by White can in principle be decreased either by enlarging the area, or by setting aside other similar areas not subjected to the same fires, pollution sources, or drainage. Our research does not address these questions.

We did not suggest in our article that multiple small reserves are preferable to fewer larger ones. To the contrary, the policy of concentrating on acquiring unique habitats, scenery, and important landmarks, reflecting multiple and diverse objectives, appears to have been an effective conservation strategy, and we urge that it not be dramatically shifted to accommodate fashionable ecological generalizations. Endangered species are undoubtedly best preserved by preserving their habitats and resources, and rainforest conservation is probably better served by effective lobbying than by pure science. We hope that many large parks ultimately will emerge.

There has been a danger in our experience, however, of denigrating the value of small parks simply because they are small. We have repeatedly encountered claims that targeted areas are "below the minimum critical size" used to oppose conservation efforts. Since the opportunities for the establishment of more very large parks seem limited, it is in numerous smaller areas that our best future opportunities may lie. Dubious ecological theory should not be allowed to derail such efforts.

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A new report, "Regulating Mineral Activity in NPS Units," prepared by the NPS Energy, Mining and Minerals Division, is now available from the NPS Office of Natural Resources. The report explains why mineral activities are generally prohibited within parks, describes the three types of such activity that personnel may encounter in NPS units, and discusses how the NPS regulates them.

Three other reports available from this series are: (1) "Using Vegetation Biomonitors to Assess Air Pollution Injury in National Parks: Milkweed Survey, a manual for use in evaluating conditions on milkweed that indicate presence or absence of air pollutants; (2) Permit Application Guidance for New Air Pollution Sources," providing guidance for submitting a Prevention of Significant Deterioration (PSD) permit application for a major source with potential to affect a Class I area; and (3) "Field Survey of *Giardia* in Streams and Wildlife of the Glacier Gorge and Loch Vale Basins, Rocky Mountain NP," giving results of a survey for *Giardia* and indicator bacteria in two popular, high elevation watersheds in Rocky Mountain NP.

For any of these reports, write Karen Simpson, Natural Resources Report Series, Office of Natural Resources MS-470, National Park Service, P.O. Box 37127, Washington, DC 20013-7127.

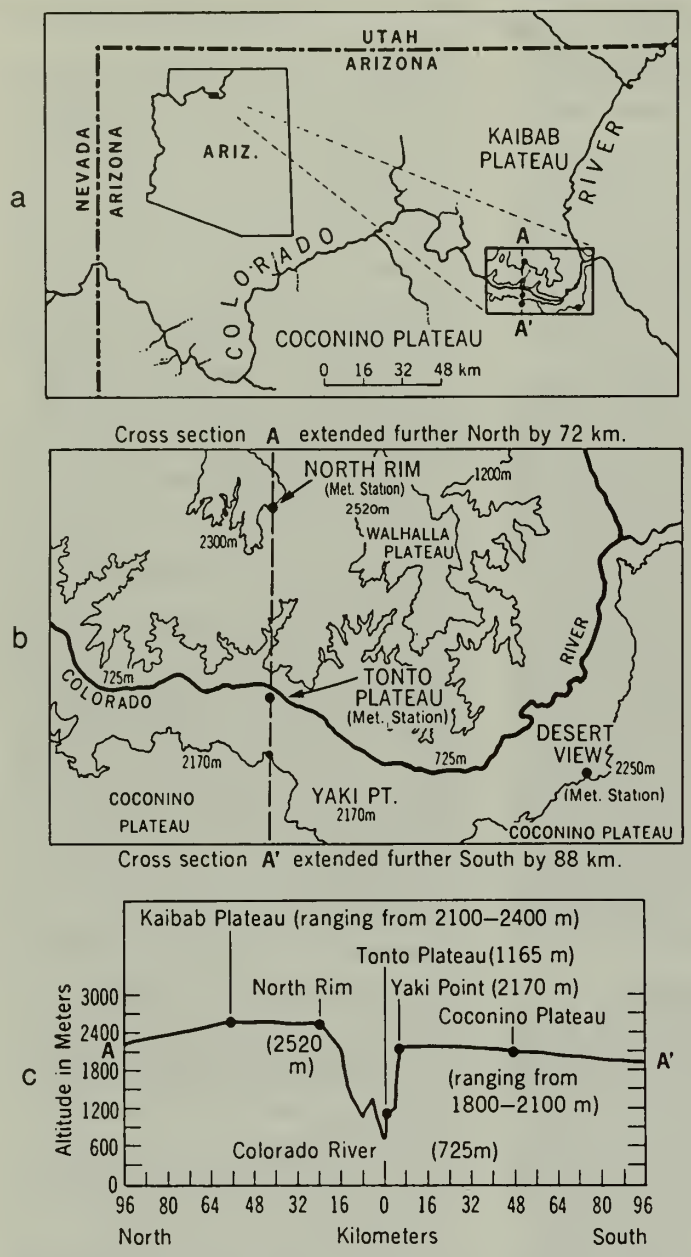

Figure 1. The Grand Canyon and vicinity in plan view (a and b) and cross-section (c).

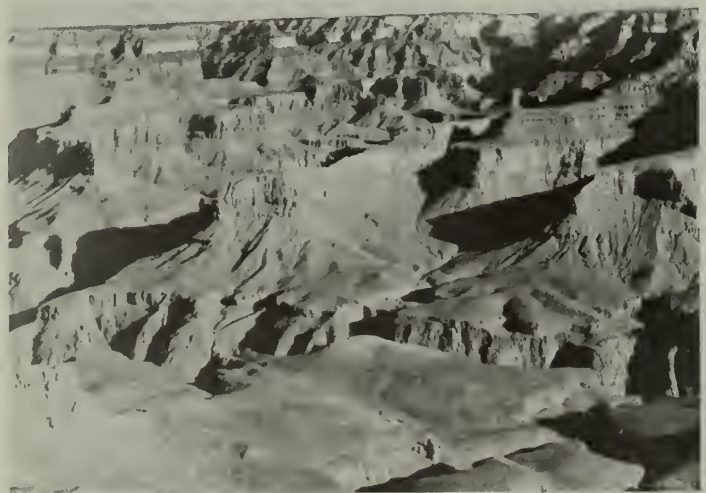

Figure 2. The research area, looking north from Yaki Point. (Photograph was provided by John Ray, Resource Management Specialist, Grand Canyon National Park).

Grand Canyon Wind Study Aids In Smoke Management

By Joe Boatman and Donald Henderson

The Grand Canyon is located in north central Arizona (Fig. 1a). South of the abyss the terrain is relatively flat and averages about 2200 m above mean sea level (MSL); to the north, the terrain is more rolling and has an average elevation of 2500 m MSL. The inner gorge of the Canyon drops to 600 m MSL. This complex topography creates markedly variable winds near and, especially, within the Canyon.

The terrain near both the south and north rims of the Grand Canyon is heavily forested; therefore, controlled burning has become necessary along both rims to meet resource management objectives. This burning is done during the spring and fall of the year when the forest is dry and cool. A significant amount of smoke is produced, creating the potential for reduced visibility and a concomitant decrease in the Canyon's scenic splendor (Fig. 2). Another problem is that the wood smoke, on occasion, could be transported from the burn site into the small town of Tusayan, along the Canyon's south rim, causing annoyance to residents and visitors alike.

The Resource Management personnel at the Grand Canyon requested assistance in developing a weather-dependent plan to minimize these problems by gaining a better understanding of the local winds in and near the Grand Canyon. We have proposed a conceptual model for the winds in the Grand Canyon and made surface, balloon, and aircraft observations in the Canyon in support of the conceptualization.

The climate of the area near the Grand Canyon can be described as sunny and dry throughout most of the year. Winds are predominantly from the southwest; however, during winter months, weak to moderate cold frontal passages do produce periods of northerly winds. It has been shown that visibility near the Canyon averages about 250 km; however, it may drop to less than 80 km on polluted or hazy days. Visibility is best during periods of northerly winds and at its worst during episodes of southerly winds. Variations in visibility result from man-made and natural causes.

Figures 1b and 1c show a plan view and cross-section of the portion of the Grand Canyon studied for this work. Only about 10% of the 300-km-long Canyon was examined. This portion of the Canyon is aligned in a roughly eastward direction and averages 9 km across and 1.7 km deep, giving it a depth-to-width ratio of about 0.2.

The winds in the Grand Canyon have not, to our knowledge, been subject to a quantitative inquiry by other researchers. Figure 1c demonstrates that the Grand Canyon is a large topographic notch, to first order. To date the only laboratory and theoretical studies of fluid flow over notches are for notch height-to-width ratios of 1.0 or greater. A considerable body of knowledge does exist that describes the airflow over cavities and abrupt steps. It is in the case of rectangular cavities and backsteps that the proper aspect ratios (0.2) are simulated.

A conceptual model for the mean air motions in the Grand Canyon was developed using cavity flow. The conceptual model was enhanced after close examination of the Grand Canyon wind data available to us. Conversely, the wind data became more understandable and consistent when placed in this conceptual framework.

Consider first the case of coupled flow (where air from above and below the canyon's rim is interacting) either during the day or at night. We propose that the mean winds in the Grand Canyon, under these conditions, are of the type shown in figures 3a and 3b. Figure 3a is a plan view of the wind pattern; figure 3b is a cross-section view. Figure 3a suggests that air below the level of the Canyon rim moves predominantly parallel to the Canyon itself. The depiction indicates that the direction of this parallel motion is always along the direction of the airflow crossing above the Canyon. That is, air within the Canyon moves eastward (west wind) when the synoptic-scale winds are from the west. The reverse occurs when synoptic-scale winds are from the east. Figure 3a also indicates that the air below the Canyon rim is undergoing a spiral motion. This is due to the secondary cavity flow. Figure 3b depicts this flow in cross-section. The secondary cavity flow is proposed to produce updrafts along the upwind walls of the Canyon and downdrafts along the downwind walls. The air in the center of the Canyon is proposed to have no vertical motion. A secondary air current counter to the prevailing synoptic flow is proposed to occur at the bottom of the Canyon.

Consider second the case of decoupled flow (where air from above and below the canyon's rim is *not* interacting), either during the day or at night. We propose that the mean winds in the Grand Canyon are of the type shown in Figures 4a and 4b under these conditions. Figure 4a is a plan view of the wind pattern. Figure 4b

is a cross-section view. Figure 4a suggests that air below the level of the Canyon rim is undergoing drainage flow. Figure 4b suggests that no secondary cross-canyon flow is present under decoupled conditions. The potentially stable air below the Canyon rim is proposed to drain gently downriver (into the paper in Fig. 4b).

Two data sets were available to test the model we proposed. The first was produced by a set of three wind sensors deployed near to and within the Grand Canyon. The second was a set of 39 pilot balloon launches made from within the Canyon.

The wind sensors consisted of standard wind vanes and cup anemometers. They were deployed atop 10 m towers in each case. Figure 1 shows their locations. Each data collecting system was solar powered and transmitted average wind velocity via satellite to a receiver in Fort Collins, Colo., once per hour. Data collection began during September, 1983. Data for one year were analyzed for this work.

A series of 39 pilot balloon launches were made during Sept. 25-28, 1984, from the Tonto Plateau site depicted in Figure 1b. The balloons were tracked using two theodolites separated by 657 m. Triangulation yielded the horizontal and vertical winds as each balloon rose.

The results we obtained using the two data sets include the following:

1) Airflow below the rim level moves predominately parallel to the Canyon during coupled flow conditions which may occur during any month of the year.
2) The secondary "cavity flow" suggested in our conceptualization occurs predominately during coupled conditions. These conditions are most often associated with periods of clear days and nights.
3) A strong shear layer was often present near the Canyon's rim level. Air below this layer appeared to be draining gently downriver. Above this layer, synoptic-scale forces predominated.
4) Winter months appeared more prone to decoupled (or drainage flow) behavior within the Canyon. It may be that potentially cold air from radiative cooling, frontal passages or snow at the rim is responsible for this.
5) Shear layers were present at lower levels within the Canyon. They may have been the product of a slow erosion process from above or the establishment of a radiation inversion. They appeared to act as an alternate bottom to the Canyon for airflow purposes.
6) At times, scouring occurred instead of secondary cavity flow. This may have been limited to very light wind cases or instances where shear layers established an alternate bottom to the Canyon.

A number of measurements important to understanding the airflow in the Grand Canyon have yet to be made. They include the vertical temperature structure, vertical wind velocities near the rims, and the radiant energy flux from the Canyon walls. An instrumented aircraft is being used to collect the appropriate data.

Final recommendations await further analysis of these additional data. The Pielke mesoscale flow model is being applied in the Grand Canyon area to obtain a better understanding of local wind flow characteristics. If our simplified conceptual airflow model is correct, it would be unwise to burn during periods when stable air fills the Canyon. This could occur during times of synoptic scale subsidence; as the result of cold outflow from passing thunderstorms (as we observed); as the result of cold air outbreaks after frontal passages; during periods of radiative cooling; or finally, as a result of snow along the Canyon rims creating a mechanism for cold air to sink into the Canyon.

To forecast the onset of such adverse conditions adequately we suggest that standard synoptic-scale data plus meteorological information from the Canyon rim and Tonto Plateau would be necessary. Standard forecasting procedures could be used to predict cloudiness, subsidence conditions, cold air outbreaks, frontal passages, or snow. On the days when burning is forecast to be feasible, winds and temperature at the Canyon rim and Tonto Plateau would be scrutinized for the presence of coupled airflow. If coupled flow were present, burning could commence. Burning would be discontinued if decoupled behavior began to appear.

To diminish the annoyance posed by burning, it will be necessary to minimize it at times when winds would carry smoke into the town. Our preliminary suggestion is that only very limited burning be undertaken at the south rim when synoptic-scale northerly flow could carry smoke into Tusayan. If northerly flow were not forecast, burning could commence, but winds at the south rim would need to be monitored for evidence of any switch to a northerly component. If such a switch were detected, burning would need to be discontinued. Burning on the south rim after sunset should be minimized because of the possibility of drainage flow away from the Canyon and into Tusayan.

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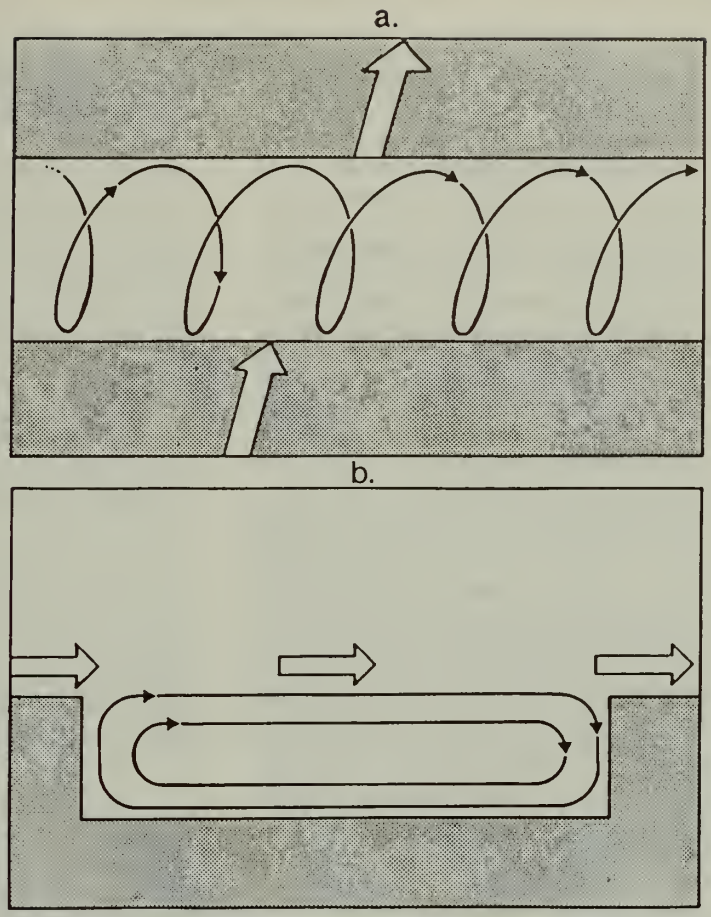

Figure 3. Wind pattern in the Grand Canyon under coupled conditions: (a) a plan view and (b) a cross-section view.

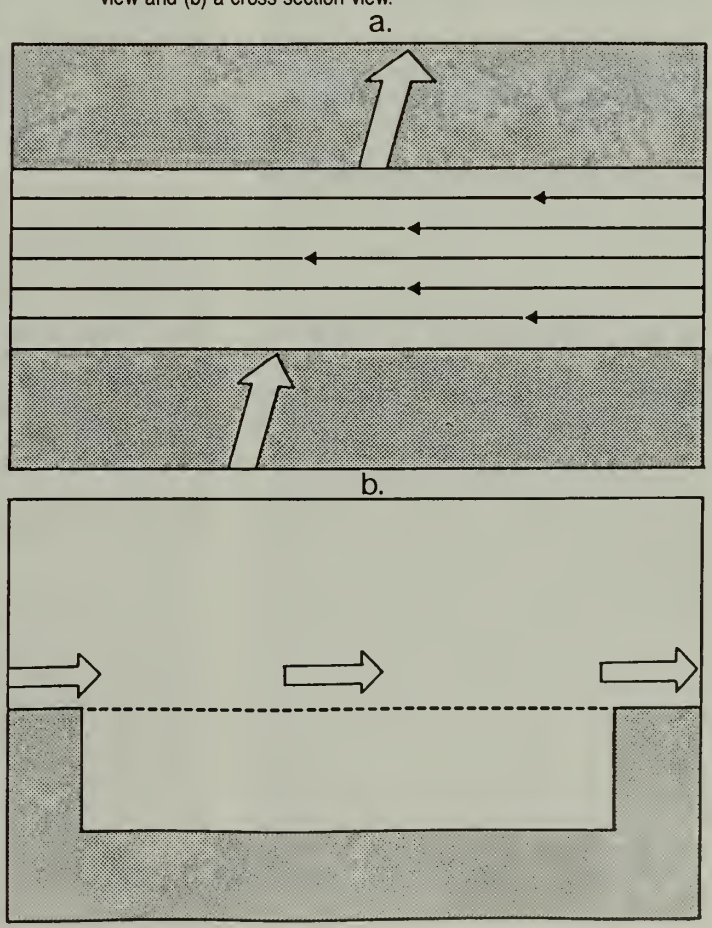

Figure 4. Wind pattern in the Grand Canyon under decoupled conditions: (a) a plan view and (b) a cross-section view.

regional highlights

The Annual Science Reports for 1985 – in some cases the fiscal year, in others, the calendar year – are appearing from the Regions and from the cooperative park studies units at the various universities throughout the country. They constitute a fairly definitive reference for the research activities underway throughout the System. If you are interested in a particular Region or CPSU, contact the Regional Chief Scientist for help in obtaining the information you seek.

Mid Atlantic Region

Continued erosion and migration of the northern end of Assateague Island NS shoreline resulting from the effects of the Ocean City, MD inlet/jetty system is the most significant resource problem facing Assateague park management. Recent research has been conducted to determine what physical changes the island will undergo if no actions are taken and to ascertain whether various measures would mitigate the problem.

Initial research, conducted by the U.S. Army Corps of Engineers, involved surveying and sediment sampling of 20 profiles along the northern 45,000 feet of the island, the development of a sediment budget for the area, and a numerical modeling analysis of historical shoreline changes of the island. Analysis of shoreline position changes from 1849 to 1980 revealed that the Ocean City Inlet and jetty system, to the north, has greatly accelerated the historic rate of island recession.

Research conducted by Rutgers University Center for Coastal and Environmental Studies examined the relationship between geomorphological factors and barrier island vegetation composition. A predictive model developed from this study can assess the consequences of future management alternatives such as the use of off-shore sand to restore historic shorelines.

A second Rutgers study assessed the morphologic, ecologic, and socio-economic effects of alternative strategies for coping with the erosion problem. This work described changes to the resource base through time, given the alternatives/scenarios and the prediction of the significance of these changes to long term management.

The final phase in management efforts to address this problem was a workshop attended by administrators and scientists representing a variety of disciplines. Workshop objectives included the identification and ranking of preferred alternatives for slowing, stopping, or reversing the accelerated erosion and the assessment of potential impacts associated with implementation of these alternatives or the no-action alternative. Three Specialty Groups (Geomorphology/Engineering; Ecology; and Socioeconomics/Planning) for in-depth discussions provided an efficient format and an Executive Summary outlining six alternatives and their impacts is being prepared. Following preparation of an Environmental Assessment, NPS administrators will make a final decision on action.

Western Region

Technical Report No. 22 from the NPS/CPSU located at the University of California, Davis, is entitled "Rare Plants of Point Reyes National Seashore and is authored by Ronilee A. Clark and Gary M. Fellers. Field surveys were conducted in 1983 and 1984 for 27 species of rare plants reported to occur at Point Reyes NS. A total of 143 populations was inventoried; 21 of the rare plant species were found. None of the other six species could be located and the authors feel it unlikely that they still exist within the Seashore.

The authors developed a photographic file of all 21 extant species and their habitats, discussed the status of all 27 species, and made management recommendations. They also mapped historic and current distribution of each of the species.

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A new Technical Report (No. 22), entitled *Rare Plants of Point Reyes National Seashore* (Clark and Fellers), was published in February, 1986, by the CPSU, University of California, Davis. It presents a description of 27 rare plants and their habitats, information on their distribution and status, and recommendations for management.

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Dr. Charles van Riper III, Leader of the California Cooperative National Park Resources Studies Unit at the University of California, Davis, has just been selected as Assistant Editor for the *Journal of Wildlife Diseases*. This journal is the official publication of the Wildlife Disease Association, an international organization of professionals who deal with diseases in wild and captive animals. Van Riper's role will be to select reviewers and to decide on the suitability of all avian disease papers submitted to the journal for publication.

* * *

Natural Resource managers gathered together last May 19-23 for the Western Regional Natural Resource Management Training Workshop in Las Vegas, Nevada. The Workshop represented the first forum in several years for Resource managers across the Region to exchange information. Participants discussed a variety of topics including obtaining information and assistance to manage park resources, competing for funds, the resource manager in 1986, and a poster session dealing with park success stories. The Workshop culminated in a field trip to Lake Mead to examine Bighorn Sheep Management practices and the rehabilitation of ORV-damaged areas.

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Hawaii Volcanoes National Park and the Cooperative National Park Resources Studies Unit of the University of Hawaii are hosting a symposium on the control of introduced plants in Hawaii's native ecosystems and the sixth conference in Natural Sciences. The symposium on introduced plants will be held June 10-12 and the conference June 13.

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Robert E. Manning has authored a new book: *Studies in Outdoor Recreation a Review and Synthesis of the Social Science Literature in Outdoor Recreation*. "This is the first systematic effort since the inception of outdoor recreation research to integrate the growing number of studies in this broad and interdisciplinary field into a body of knowledge. Emphasis is given throughout the publication on the practical management implications of the research base. It is available through the Oregon State University Press in Corvallis, Oregon.

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On March 27, Bighorn sheep were reintroduced into Yosemite National Park as part of the latest phase of the Sierra Nevada's Bighorn Sheep Recovery and Conservation Plan, a joint effort of the National Park Service, the United States Forest Service and the California Department of Fish and Game.

* * *

Gary E. Davis Research Marine Biologist at Channel Islands, was recently elected president of the American Academy of Underwater Sciences. The Academy promotes advances in science conducted underwater including such diverse disciplines as archaeology, engineering, and biology. He will assume the post at the annual meeting at Florida State University in Tallahassee, Florida, October 1986.

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"Rural Communities and Natural Resources: A Working Bibliography" is the title of CPSU/OSU 86-5 by Donald R. Field, Denver Hospodarsky, and Richard S. Converse. The 87-page document is a publication of the NPS Cooperative Park Studies Unit at the College of Forestry, Oregon State University, Corvallis, OR 97331. The bibliography focuses on papers that discuss how social aggregates respond to and alter the resource base in an interactive process of natural and social adaptation. Four functional components of community adaptation provide the major categories in which the papers are located: population, organization, environment, and technology.

Rocky Mountain

Francis J. Singer has transferred to Yellowstone NP to conduct studies of elk range relationships, population dynamics, and mortality. In 1985, Singer published two articles (co-authored with Jonathan Doberty), from studies of mountain goats during the reconstruction of U.S. Highway 2 in Glacier NP: "Managing mountain goats at a highway crossing," **Wildlife Society Bulletin** 13:469-477; and "Movements and habitat use in an unhunted population of mountain goats," **Canadian Field Naturalist** 99(2) 205-217. Singer also published "Design and construction of highway underpasses used by mountain goats" in Transportation Research Record 1016, with the two Federal Highway Administration design engineers on the project, Walt Langletz and Eugene Samuelson.

Alaska

The 1986 Alaska Interagency Moose Workshop, hosted by NPS this year, was held in Anchorage March 6. Approximately 60 participants discussed topics on habitat relationships, behavior, immobilization, predator-prey relationships, and harvest management. The workshop was followed by the Alaska Chapter of The Wildlife Society's annual meeting which focused on predator management issues in Alaska. Layne Adams, Gary Vequist and Al Lovaas of NPS spoke at the meetings.

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Dr. L. David Mech, USFWS Wildlife Research Biologist and world renowned wolf expert, is working

through the USFWS-NPS Master Memorandum of Understanding in cooperation with the natural resource management staff at Denali National Park and Preserve to study the distribution, demography, and prey relationships of wolves in the park. The project, which includes radiocollaring and intensive monitoring of wolves in the park, was initiated in February 1986 and is expected to continue through 1988.

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The NPS is proposing to dismantle a fish ladder located on the Brooks River in Katmai NP and to restore the river bank to a natural condition. The Alaska Department of Fish and Game is strongly opposed to the proposal. The ladder was constructed at Brooks Falls in 1949-1950 by the Bureau of Commercial Fisheries to assist the natural passage of sockeye salmon over the falls. Presence of the ladder is of course contrary to present NPS management policy. Genetics research and salmon escapement counts suggest the ladder has been ineffective anyway. Kathy Jope of Katmai has recently completed writing an EA on the subject.

Water Resources Division

The May 9 activities report from Fort Collins, NPS Water Resources Division, brings word of articles from an Acid Rain Symposium contained in the most recent issue of *The University of Toledo Law Review* (Vol. 17, No. 1, Fall 1985). Included are "European Community Air Pollution Abatement Policy" by Christian Cleautinx, "Public Diplomacy and Acid Rain" by Fitzhugh Green, "Acid Rain: Canadian Litigation Options in U.S. Court and Agency Proceedings" by David Wooley, and "Canadian Positions, Proposals, and the Diplomatic Dilemma: Acid Rain and Emerging International Norms" by Sydney Harris.

Southeast Region

The following technical reports are now available from the South Florida Research Center, Everglades NP, Box 279, Homestead, FL 33030 or National Technical Service, 5285 Port Royal Road, Springfield, VA 22161:

Bert, T.M.; Tilmant, J.; Dodrill, J.; and Davis, G.E. 1986. Aspects of the population dynamics and biology of the stone crab *(Menippe mercenaria)* in Everglades and Biscayne National Park as determined by trapping. SFRC-86/04.

Herndon, Alan, and Taylor, Dale. 1986. Response of a *Muhlenbergia* prairie to repeated burning: changes in above-ground biomass. SFRC-86/05.

Snyder, James R. 1986. The impact of wet season and dry season prescribed fires on Miami rock ridge pineland, Everglades NP. SFRC-86/06.

Recreation Research Colloquium

Twenty recreation scholars convened at TVA's Land Between The Lakes April 1-4, 1986, for the first Recreation Research Colloquium. Representing 13 universities and the National Park Service, they spent four days evaluating past LBL social research projects and brainstorming a list of future research topics. Their final list of 99 topics fell into five areas needing immediate LBL social research – fee structures and their impact on visitation, signage and its impact on visitation, LBL's impact on the regional economy, determination of acceptable levels of commercialization, and exploring alternate sources of revenue. For more about the colloquium or upcoming research opportunities at LBL contact Jim Carpenter, Coordinator, Professional Development, LBL, Golden Pond, Kentucky 42231, or call (502) 924-5602.

Pacific Northwest

From John Aho at Olympic NP comes word of the 1985 annual report on precipitation chemistry and ecosystem function in the park – baseline research for acid precipitation studies. The 41-page report, plus a 2-page summary, contains 11 tables and 4 figures. Research last year focused on two small watersheds of the Hoh River drainage in Olympic NP and consisted of plot sampling – vegetation and soils, precipitation and stream chemistry, and a small mammals survey.

Copies of the report may be requested from Aho, Division of Science and Technology, Olympic NP, 600 E. Park Ave., Port Angeles, WA 98362, or (206) 452-4501 x241.

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From Robert S. Chandler, superintendent of Olympic NP, comes word of the death of Don Cole on May 9, after a prolonged and valiant struggle with cancer. Wrote Chandler:

"Don came to Olympic in 1983 as this park's first fishery biologist. He added a new and very important dimension to our fish management program and was the primary person developing the very complex Elwha fish restoration project. His commitment to this work was evident in recent weeks as he continued to give the job all he could in spite of his failing health. The work that Don performed and the respect he gained from his co-workers and from other agencies helped the park establish a much stronger role in carrying out our fishery management responsibilities. We will miss Don's professionalism, his commitment, and his friendly manner."

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A skills development and information exchange workshop, addressing the practical "hands on" aspects of wilderness and backcountry site restoration projects was held April 19 at North Cascades NP. Attendants were people active and interested in restoration of human-impacted backcountry areas through applied revegetation techniques – agency personnel, students, and work crew supervisors. Content ranged from the dynamics of timberline and alpine meadow evolutionary change to plant tissue culture.

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Aldo Leopold Centennial Celebration

On Oct. 5-9, 1986, the centennial of Aldo Leopold's birth will be celebrated in his native state with a series of public lectures at Iowa State University. Out-of-town visitors are welcome, and no admission fees will be charged. Leopold's life and ideas, their influence upon the present, and their implications for the future will be among the topics of historian Roderick Nash, wildlife ecologists Raymond Dasmann and Dale McCullough, Arizona Governor Bruce Babbitt, former California Secretary for Resources Huey Johnson, political scientist Craig Allin, Leopold scholars Susan Flader, Baird Callicott, Curt Meine, and Sharon Kaufman, geologist Charles Bradley, and Leopold's four children, distinguished scholars in their own right. Contact: Thomas Tanner, Environmental Studies Program, 141 Bessey Hall, ISU, Ames, IA 50011.

information crossfile

"Conservation Biology: The Science of Scarcity and Diversity," published in May 1986 by Sinauer Associates, Inc., of Sunderland, MA 01375, and edited by Michael E. Soule, is a comprehensive overview of the scientific foundations of conservation biology – emphasizing the core fields of ecology, biogeography, and genetics. The 480 page volume consists of 25 chapters, each by a leader in the field, divided into six sections on the genetics and viability of populations, categories of diversity and rarity, the effects of fragmentation, community processes, sensitive habitats and systems, and interactions with "the real world."

According to the publishers, the chapters are "authoritative and many contain new information and original theories and models relevant to *in situ* and *ex situ* conservation." In addition, the text is said to be "replete with ideas for future research directions and opportunities," and includes a comprehensive bibliography and suggested readings appended to each chapter. Cloth books are $46.50; paperbacks, $27.00.

An NPS reviewer will assess the book in the Fall issue.

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A new entry into the information field is the *Northwest Environmental Journal,* published semiannually by the Institute for Environmental Studies at the University of Washington, Seattle. The journal covers environmental issues in Alaska, Idaho, western Montana, Oregon, Washington, and northwestern Canada. It is a refereed, multidisciplinary publication intended for a broad audience concerned with the environment. One year subscriptions are $16 U.S. Contact: Patricia Coburn, managing editor, Journal FM-12, University of Washington, Seattle 98195.

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The Spring issue of *Ranger* (Vol. II, No. 2), Journal of the Association of National Park Rangers, carries a five-page article by Scott Erickson on "Fire Management in the National Park Service." Erickson, a Park Ranger/Fire Management specialist assigned to the Washington Branch of Fire Management – a field unit located at the Boise Interagency Fire Center in Idaho – has been involved in fire suppression and management since 1965 and has been at BIFC since 1977. His overview leans heavily on Stephen Pyne's *Fire in America: A Cultural History of Wildland and Rural Fire* (Princeton University Press, 1982).

Coupled with the Erickson piece are two articles by Rick Gale, Chief Ranger at Santa Monica Mountains, ("1985 – The Year of the Fires," and "National Interagency Management Teams,") and one by Doug Erskine of the Alaska Regional Office ("Firefighting and Interagency Cooperation in Alaska").

Ranger and the *CRM Bulletin,* an NPS technical publication dealing with cultural resource management, are recommended reading – along with *Park Science* – for anyone who wants a rounded picture of NPS professionalism.

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Continued on page 22

From Tom Lucke of Ft. Collins comes the note that the latest issue of *Journal of Energy Law and Policy,* Vol. 4, No. 1, 1986, contains two articles pertaining to the National Park Service. They are "The National Park Service Organic Act Prohibits Turning the Doorstep of Canyonlands National Park into a Nuclear Wasteland" by Julie A. Bryan (pp. 95-121), and "Protecting National Park System Buffer Zones: Existing, Proposed, and Suggested Authority" by John W. Hiscock (pp. 35-93). The former develops arguments against the proposed Department of Energy's nuclear waste repository sites at Davis and Lavander Canyons near Canyonlands National Park, and the latter reviews existing and proposes new legislation to protect parks related to development within or outside their boundaries.

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Six human-induced grizzly bear mortalities took place in the Yellowstone ecosystem in 1985 according to the fourth edition of *Grizzly Bear Recovery Notes,* published by the Interagency Grizzly Bear Committee, Chris Servheen, coordinator, (HS 105D, University of Montana, Missoula, MT 59812).

Major research projects in the Yellowstone area in 1985 included the second year of work on impacts of backcountry recreation on grizzly bear behavior and habitat use. A report on this study was distributed to IGBC members in October 1985. Studies continue on ways to monitor grizzly population trends.

Development of the cumulative effects analysis process is continuing for the Yellowstone ecosystem, using computerized mapping of habitat values as well as human influences. The process is being tested on certain bear management units and it is hoped that it will be running for the entire Yellowstone ecosystem sometime in 1986.

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Water law is the subject of the winter 1986 issue (Vol. 1, No. 4) of *Natural Resources and Environment.* Among the articles are "Western Water Law" by Roderick Walston, "Eastern Water Law" by George Sherk, "The Historic Relationship of Water Quantity and Water Quality" by George Vranesh, and "Federal Environmental Law and State Water Law: Accommodation on Preemption" by Gregory Hobbs.

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Canaveral Sea Turtle Strategy Defeats Raccoons

In 1982, Jennifer McMurtray of the University of Georgia NPS/CPSU, began to investigate hatching success of sea turtle nests on Canaveral National Seashore. Canaveral is one of the most important remaining nesting beaches for loggerhead sea turtles, supporting over 2,000 nests per year, and is also used by endangered green turtles and rarely, by hawksbills and leatherback turtles. McMurtray found that raccoon depredation was destroying nearly all sea turtle nests. Nest survivorship was less than 2% in the five-mile long study area and raccoons raided most nests within the first few hours after deposition. Researchers observed that raccoons sometimes consumed eggs while female turtles were still laying and had not yet covered the nest.

In 1983 McMurtray began to experimentally screen nests to discourage raccoons. Of the two screen designs employed, a four-by-four foot piece of dog wire (2 x 4-inch mesh) was the most practical. Clog wire has large enough openings that hatchling turtles can emerge while the screen is still in place. Other methods of discouraging raccoons, such as the use of human urine to scent nest locations, were found to be ineffective.

In 1984, Supt. Art Graham designated the protection of threatened or endangered sea turtle species as a priority resources managment goal for the park. Graham initiated a new program in which seasonal technicians patrol nesting beaches, screen nests and if necessary, remove especially troublesome raccoons. At the end of two summer seasons, the program has significantly improved nest survivorship.

Richard Bryant, park technician in charge of the 1985 effort, reported a total of 2,508 nests deposited on Canaveral beaches, including 94 green turtle nests. Workers screened 1,023 nests. Storms destroyed 133 of these, while raccoons invaded 51. The remaining 839 nests hatched an average of 96 hatchlings each. Screening thus allowed an estimated 80,500 hatchlings to enter the ocean.

The program has not only reduced predation on screened sea turtle nests, but workers have observed fewer raccoons on the beach. The program may therefore also be providing some protection to *un*screened nests. Reports on McMurtray's original study and on the successful 1985 management program have been issued by the NPS/CPSU at the University of Georgia.

Contact: Canaveral National Seashore, P.O. Box 6447, Titusville, FL 32782-6447 or NPS/CPSU, Institute of Ecology, University of Georgia, Athens, GA 30602.

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United States District Court Finds Reserved Water Rights In Federal Wilderness Areas

By Thomas W. Lucke

In *Sierra Club v. Block,* No. 84-K-2 (D. Colo. 1985), the United States District of Colorado held that Congress, in passing the Wilderness Act of 1965, impliedly reserved to the U.S. Government a right to previously unappropriated water in Colorado Wilderness Areas managed by the U.S. Forest Service. In addition, the court held that the Wilderness Act created an affirmative duty for the Secretary of Agriculture to protect the government's right to water in designated wilderness areas.

The court, however, declined to rule that the Secretary of Agriculture acted arbitrarily or capriciously in not asserting a water right to fulfill the purposes behind wilderness areas. Instead, the District Court ordered the Secretary of Agriculture and the U.S. Forest Service to submit to it a memorandum explaining what they will do in the future to comply with the Wilderness Act's requirements that they protect water resources in wilderness areas.

The District Court, in its opinion, referred to *Winters v. United States* (1908), a U.S. Supreme Court case which first enunciated the principal that Congress' reservation of lands for a specific purpose impliedly reserves a sufficient amount of water to fulfill that purpose. This rationale developed by the court would indicate that a similar ruling would have been made if the wilderness areas involved were managed by any other Federal agency such as the Fish and Wildlife Service or the Bureau of Land Management.

Thomas W. Lucke is Chief, Water Resources Division, National Park Service, in Ft. Collins, Colorado.

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John P. Wiley's regular column in the *Smithsonian* magazine (Phenomena, comment and notes) in the March issue is devoted to a discussion of *The Ecology of Natural Disturbance and Patch Dynamics,* edited by Peter White and S.T.A. Pickett. The book evidently was a real revelation to Wiley, who found his whole vision of the world changing as he mulled the two-way error into which Pickett and White argue that biologists can fall: they may erroneously extrapolate from measurements made during disturbance-free years to predict the future, and they may use a scale for their studies that masks patches of very different character.

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A new report, "Ecological Knowledge and Environmental Problem-Solving," (available from the National Academy Press, 2101 Constitution Ave., N.W., Washington, DC 20418, $24.50), is reviewed in the April 4, 1986 *Science* (Vol. 232, pp. 24-26.) The report argues that it is not the lack of ecological information that leads to poor environmental planning, but simply the lack of its proper application.

Two major conclusions of the report:

First, that environmental impact statements could be viewed as true scientific hypotheses about how the environment will be affected by a particular project (instead of being written merely to satisfy various legal requirements). Correct monitoring would constitute an ecological experiment on a scale greater than anything for which conventional funding agencies would be likely to provide. Information thus gained could then be applied to future projects of like nature. (See "Managing Wildlife with Experimental Rigor" in Spring 1985 *Park Science,* Vol. 5, No. 3, p. 13.)

Second, that insidious effects of cumulative perturbations too often do not show up when the study is based on a single project. Gordon Orions, Chairman of the National Research Council's Committee on the Applications of Ecological Theory to Environmental Problems and spokesman for his committee's report, decried the present lack of clear regulatory responsibility for recognizing such aggregate changes. The problem, said Orions, is that "Environmental laws approach problem-solving on a case-by-case basis. This makes it very difficult to recognize the cumulative impact of the environmental changes under consideration."

In this regard, the identification of "thresholds" is seen by the report to be a major shortcoming. Particular questions abound and our knowledge is often far below what is needed to make good predictions.

The heart of the report consists of 13 case studies, ranging from attempts to destroy or to preserve single species to management of perturbations on whole ecological communities. According to Roger Lewin, who reviewed the report for *Science,* "The case studies represent the real strength of the report."

Out of the case studies comes the realization that much of what we think we know is faulty. Complex ecosystems give rise to nuances that are not necessarily predictable. Case studies reveal these nuances and our managerial shortcomings.

The report's major recommendations include the following:

(1) Involve scientists from the beginning; (2) treat projects as experiments; (3) use natural history information; (4) be alert for cumulative effects; (5) prepare for uncertainty and think probabilistically; (6) set proper boundaries on the projects.

According to Orions, the science of ecology is emerging from a rather general theoretical modeling stage to a new phase of "regrouping around more modest models." The combination of these more modest models with empirical evidence, he feels, has the potential to contribute to sound environmental planning.

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In one of the largest surveys ever made of contaminants in arctic wildlife, toxic chemicals were widely present in polar bears, seals, and fish. The findings were reported by Ross Norstrom of the Canadian Wildlife Service at the Second World Conference on Large Lakes. The study involved examination of liver and skin samples from 144 polar bears and was done in cooperation with Inuit hunters in arctic Canada. The contaminants, many of which fall under the general category of organochlorines, are carried to the arctic on the wind, from thousands of miles away.

Wolves Down, Moose Up At Isle Royale NP

From the Midwest Region comes word that the number of wolves on Isle Royale NP is down slightly this year, but the island's moose population continues to increase gradually.

Rolf Peterson, Michigan Tech University biologist now under contract to the NPS, completed his annual winter wolf-moose population survey in the park, and reported that six of the 22 wolves there last year have died or disappeared. These losses, however, have been partially offset by the survival of four pups born last summer, bringing the total population to 20. Fate of most of the wolves lost from last year's population is not known, but at least one of the six was a victim of interpack warfare.

"We know that one member of the Harvey Lake Pack, which occupied the middle portion of the island, was killed by the East Pack when it invaded the Harvey Lake territory," said Peterson. "We came upon the East Pack just after they had killed the Harvey Lake wolf and had begun scent-marking their new territory."

An Alpha (dominant) female of the Harvey Lake Pack had been killed two years ago, reducing the pack's numbers to three. With this year's death, the two remaining members have dispersed and the group is no longer functional as a pack. As a result, the West Pack, numbering 11 animals, now controls two-thirds of the island, while the five-member Northeast Pack controls the remaining third." Peterson said the West Pack raised three new pups this year, while the East Pack added one.

According to Peterson Isle Royale's wolves are having a difficult time finding weak or sick moose to kill because the moose herd is in relatively good condition. He expects this situation to prevail until the end of this decade when many members of the herd will reach an age when their weakened condition will make them more susceptible to wolf predation.

While conditions for wolf survival are less than optimal, Isle Royale's moose population has continued to increase gradually to 1,025.

Seabird Condos Readied At Channel Islands NP

By Gary Davis

Monitoring nesting success of seabirds is an important part of managing Channel Islands National Park and National Marine Sanctuary, located 6 to 31 miles off the southern California coast. In late January, 1986, the National Park Service installed two small observation platforms and 50 nesting boxes to assist park resource managers to monitor Cassin's auklets on Prince Island, a four hectare rock marking the northern boundary of Cuyler Harbor at San Miguel Island. The Prince Island seabird colony is the largest in southern California, with an estimated 20,000 auklets sharing the small island with breeding colonies of Brandt's, double crested, and pelagic cormorants, western gulls, ashy and Leach's storm-petrels, pigeon guillemots, black oystercatchers, and Xantus' murrelets.

Cassin's auklets dig burrows in soft sea cliffs on Prince Island for their nests, riddling the colony area with 10,000 holes. To prevent collapsing their burrows during censuses, two observation platforms, each a foot wide and 35' long, were installed in the colony before the birds returned for this year's nesting. From these platforms, resource managers will be able to determine occupancy rate in the colony and assess nesting success in subsequent years. Below each platform, 25 nesting boxes were also installed. The boxes all have a floor plan copied from natural burrows and tested in an auklet colony on the Farallon Islands, near San Francisco.

The park staff quickly labeled the boxes "condominiums" when they saw their identical external appearances and "floor plans." The 3½ inch wide entrances lead down gently sloping hallways a foot and a half into a cozy (8" x 8") nest chamber offset to the right. The boxes are partially buried in the sea cliff to shelter them from sun and wind. The roof of the nesting chamber is held in place by a rock, but may be removed to conduct periodic censuses to determine numbers of eggs laid, hatching success, and condition of chicks.

Cassin's auklets breed from the Aleutian Islands in Alaska to Isla San Rogue off Baja California, Mexico. Since they burrow in the ground, their colonies need to be in places where predators can't get to their nests. They also need to be close to ample supplies of food. Offshore islands and rocks are their best refuge, but there aren't very many of these; the park offers the best locations in southern California with protection from human disturbance.

Egg laying generally begins in March at the Prince Island colony. Each pair of auklets produces only one egg per year, and only about a third to one half of the eggs laid actually hatch. Producing young auklets is a chancy proposition even under the best of conditions. Young birds leave their nests and learn to fly during the summer months from June through Au-

Continued on back cover

***Cassin's auklets** will have this view from their new nesting box "condos" on the north shore of Prince Island in Channel Islands NP, Calif. The wooden observation platform over the nesting boxes will provide monitoring access without danger of collapsing underground tunnels.*

PARK SCIENCE

NATIONAL PARK SERVICE
U.S. Department of the Interior

In the Next Issue:

Our editorial eyes are proving consistently to be bigger than our layout space stomach, so no more promises as to what will appear in the next issue. Two full pages of overset are all we guarantee!

Seabird Condos

Continued from page 23

gust. They are diving birds, feeding primarily on fish and euphausid shrimp from offshore waters near San Miguel Island. They are especially vulnerable to oil pollution, and therefore serve as sensitive indicators of environmental conditions in the park.

Seabirds are important indicators of the health of marine and coastal ecosystems. A drastic decline in the number of young brown pelicans provided a dramatic warning of DDT pesticide contamination off the southern California coast in the 1960s. As they stumbled and then recovered in the 1970s and 1980s, they reflected improvements in the health of coastal ecosystems. California brown pelicans are now recovering, but the vigil must go on.

Davis is a Research Marine Biologist at Channel Islands NP, Ventura, Calif. 93001.