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# PARK SCIENCE

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**Cover photo:** Tagging a 45 mm stonefly presents somewhat different problems than tagging a white-tailed deer. The whitish patch on the upper shoulder of the stonefly in the cover photo shows abrasion of the original tag. Better placement of the second tag (#1487) solved the recapture identification problem. The stonefly story is on page 3. The deer article begins on page 4.

### Editorial

It will perhaps come as no great surprise to scientists, resource managers, and superintendents of the National Park Service to learn that chaos is a fact of life.

What may be of interest, however, is the recent jelling of a suspicion that – like the word “magic” – the word “chaos” may simply be a convenient semantic designation for something we don't yet understand.

In a new book titled *Chaos: Making a New Science*, (Penguin paperback \$8.95), James Gleick describes an “upstart new science” – the study of the circumstances that lead otherwise smooth, dynamic processes to disintegrate into chaotic, unpredictable behavior. According to Gleick, chaos theory can be applied to such diverse phenomena as weather prediction, cancer growth, heart attacks, and business cycles.

The science of chaos challenges two heretofore widespread scientific notions: the idea of *reductionism* (breaking the whole into pieces and assuming that the whole is the sum of the pieces), and the notion of *predictability*. The new science attacks reductionism by asserting that instead of acting independently, the various “pieces” of a system act on every other piece so that any change in any of the components will alter the system throughout. The notion of predictability had already been upended by quantum physics, which trashed forever the boast of 18th century philosopher/mathematician Pierre Simon de Laplace that given the position and velocity of every particle in the universe he could predict the future for the rest of time.

Real world situations are complex, and the interaction of a few of even the simplest of a system's components can generate randomness and make prediction impossible. Ask any weatherman. The minutest of differences (sometimes referred to as “the butterfly wing effect”) will be amplified over time in unpredictable ways.

For those with a mathematical turn of mind, the consideration of fractals (which describe the nooks, crannies and twists of nature) as a tool in the new science will glue you to the pages of this book.

For those of a more philosophic bent, a prior reading of Fritjof Capra's *The Tao of Physics* will suggest that perhaps randomness and chaos are only the three dimensional manifestations of a cohesive and orderly pattern that can express itself fully only in five, ten, or a thousand dimensions ... much as a closed circle that intersects a flat world at only two points as it completes its third dimensional loop would be seen by two-dimensional (flat world) creatures as two totally unrelated “holes in their world.”

Next time your star-gazing interpretive program is clouded out, or the campground plumbing fails, or your enclosure fencing is destroyed (the indoor flushing won't go down the drain but your outdoor experiment does), try to think of it as a seemingly disorderly manifestation of an unfathomable order – *somewhere!*

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# Superglue-tagged Stoneflies Aid Aquatic Food Web Research

By Jerry Freilich

Wildlife biologists and resource managers today routinely tag many kinds of animals to study home range, dispersal, and interactions among individuals. We read of tagging studies on bird species, wolves, bears, and even fish. My research adds a new and perhaps surprising creature to the list of tagged animals. I've been tagging individual stonefly nymphs (*Pteronarcys californica*) in Pacific Creek, Grand Teton National Park, Wyo.

Stoneflies (insect order Plecoptera) are important in the life of a stream. Most are predators feeding on mayflies and other aquatic insects. As such, they are vital components of aquatic food webs. The species I am studying, commonly called the Salmonfly, is the largest North American stonefly (reaching > 50 mm). It is a leaf-shredder and detritivore rather than a predator. These insects are especially important because their leaf-shredding activity creates fine particulate organic matter (FPOM) eaten by other insects. They're also important because they're large and thus too big for all but large fish to eat. *Pteronarcys* has a prolonged life-cycle, spending 3 years as an aquatic nymph. Their emergence as winged adults in early summer is as much anticipated by the flyfishing public as by the ravenous fish.

Tagging aquatic insects proved to be difficult (see general references in Walker and Wineriter 1981,

Wineriter and Walker 1984, and Emery and Wydoski 1987). Very few existing studies have done it, and most of those were conducted in either "lab streams" or slow water. I devised a method that worked on insects living in turbulent riffles and burrowing under rocks. The procedure that finally evolved uses plastic paper tags attached with gel-type Duro Super Glue™ (Loctite Inc., Newington, CT). Each tag is 2 x 3 mm and carries a 4 digit number. I learned that the tag's location on the insect is critical. Tags in the wrong location were badly abraded by the rocks and gravel in the streambed. I would be happy to provide other workers a detailed protocol for creating the tags, sealing them with clear epoxy, and attaching them.

## Why Tag Aquatic Insects?

Most terrestrial ecologists could probably answer the question "what controls animal populations?" at least in general terms. In aquatic ecosystems, however, this question still is controversial (Hart 1983). Even such questions as whether predators control prey, or whether food is limiting in streams are largely unresolved.

My Ph.D. project involves resource limitation and intraspecific competition in *Pteronarcys*. I am trying to learn which factors influence the movement of individual insects in a stream. To do this I tagged 1500



Adult stonefly can reach 50 mm from stem to stern.

individuals in 2 seasons of field work. In 1987, I tagged 1008 and released them at the same place where they were caught. In 1988, I performed an experiment where I modified food and stonefly density in 36, 4m<sup>2</sup> quadrats.

## Results from 1987

Head capsule widths showed that *Pteronarcys* has a 3 year life cycle in Pacific Creek. Females were larger than males (maximum 56 mm body length, 6.0 mm head width). Males reached 47 mm (5.1 mm head width). Only 2nd and 3rd year males and females were tagged. I recaptured 249 of the 1008 tagged (25%) between August and November.

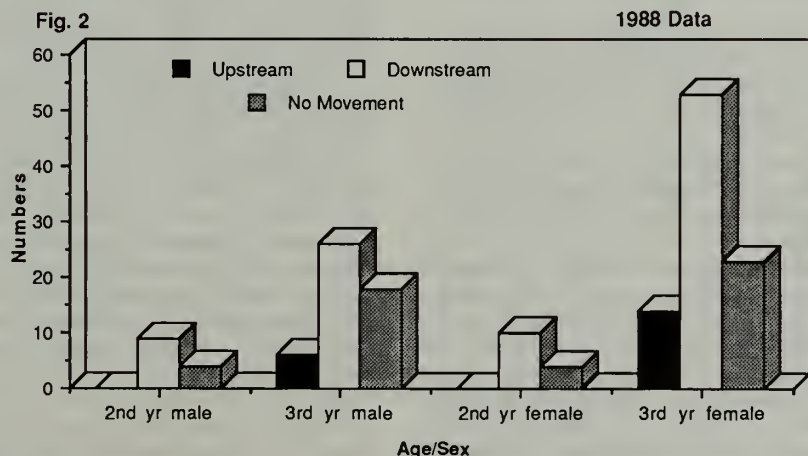
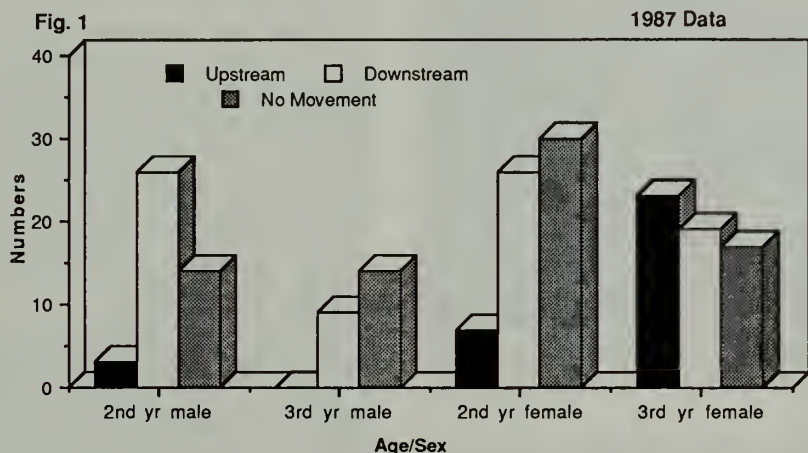
*Pteronarcys* were found in areas of fast, deep water with large, loosely bedded cobbles. None was ever found in a pool nor in an area with silty or fine gravel bottom. No tagged stonefly ever crossed a pool. Individuals of the same sex and size frequently were found together, a previously reported phenomenon (Elder and Gauvin 1973).

Results show that upstream movement largely balanced downstream movement. But all movements averaged -2.71 (i.e., downstream 2.71 m) if zero movements are removed. The absolute value of all movements averaged 9.05 m, with zero movements deleted.

A large percentage (43%) of the stoneflies recaptured were found at the same spot as their previous capture. Forty percent moved downstream and 17 percent moved upstream. Forty-two *Pteronarcys* were recaptured twice, 10 were recaptured 3 times, and 2 were recaptured 4 times. Multiple recaptures showed that an individual may move long distances in a short time and then sit in the same place for weeks before moving again.

A very few individuals were notable for extremely rapid upstream movements. These movements ranged from 6-22 m/d upstream (mean 10.6 m/d, n=8). The farthest upstream traveler was a large female that moved 40 m upstream in 4 days. The fastest was another large female that covered 22 m upstream in a single day. Upstream movement is clear evidence of self-propelled activity. Corresponding downstream movement could be attributed to drift, although not necessarily. ("Drift" is the well-known phenomenon of insects moving downstream with the current. *Pteronarcys* drifted little if at all).

One way ANOVA (analysis of variance) comparing the distances moved by males and females shows significant difference between the sexes. Figure 1 (based on a subset of the *Pteronarcys* that were



Graphs showing numbers of recaptured *Pteronarcys* stoneflies in 1987 (Fig. 1) and 1988 (Fig. 2) by sex and age class. In 1987, N=188 that were reliably sexed. In 1988, N=214 recaptures.

Continued on next page



# White-Tailed Deer Ecology on Fire Island

By Allan F. O'Connell, Jr., Mark W. Sayre,  
Edward M. Bosler, and Henry Art

White-tailed deer (*Odocoileus virginianus*) are well known for their adaptability and propensity to overpopulate their range if not regulated. This trait, along with an association to Lyme disease, has sparked increasing concern over deer populations in many states. Fire Island, along with much of the Northeast, sections of the Midwest (Wisconsin, Minnesota) and portions of California and Oregon, is now an endemic focus for human Lyme disease.

Steady growth of Fire Island's (FI) deer population over the past 10-15 years has followed this scenario. A lack of natural predators, little snow accumulation, a series of relatively mild winters, supplemental feeding by FI residents, and limited "off-island" dispersal opportunities (due to mainland suburban development) have fueled population growth. In the early 1980s, complaints of deer feeding on horticultural vegetation, deer-human conflicts, public pressure to reduce deer numbers, and the documented presence of human Lyme disease cases on FI, prompted a study of the deer population. FI deer, as hosts for the northern deer tick (*Ixodes dammini*), (the primary vector of Lyme disease in the Northeast), have been implicated in the Lyme disease transmission cycle.

Little information existed on FI deer (and barrier island deer populations in general) prior to this study, so several different samples (aerial censuses, winter mortality, vegetation exclosures, blood, tissue, and rumen) were used to evaluate the condition and the annual fluctuation of this population.

Research was conducted by the U/Mass Department of Forestry and Wildlife Management and the NPS North Atlantic Region through a cooperative agreement. Under an Inter Personnel Agreement (IPA), the principal author conducted data analysis at U/Mass as partial fulfillment of a doctoral degree in wildlife ecology and management.



Handling immobilized deer on Fire Island.

Although deer were rarely observed on FI in the early 1970s, their population increased dramatically in the last several years. Aerial censuses, designed with the help of Jim Allen (NARO), revealed a population that nearly doubled between 1983 and 1988. Confronted with a limited opportunity to disperse off FI, increasing numbers have forced deer into FI's human communities.

Data also show that deer are severely hindering regeneration of herbaceous perennials in FI's maritime forest ecosystem. Wildflowers such as aralia (*Aralia nudicalis*) and starflower (*Trientalis borealis*) currently are found growing only among dense tangles of catbrier, which deer cannot penetrate. These species

are beginning to revegetate within deer exclosures. Impacts on vegetation are further evidenced by examining rumen contents. Pitch pine (*Pinus rigida*) needles were found to be a fairly common food of deer even during the summer months, at a time when deer are normally feeding on succulent leaves and fruits to store fat for the winter.

As deer populations increase, they are more subject to environmental perturbations. Detrimental effects of hurricane Gloria (September 1985) were evident in FI's deer population. Due to hurricane force winds (160 km/hr), a large amount of sand was re-deposited and salt spray moved over FI's entire land mass, resulting in premature deciduous plant leaf senescence. Even highly tolerant conifers like pitch pine were stressed by the salt as evidenced by needles turning orange and a significant needle loss. Thus, food available for winter fat storage was greatly reduced.

Serum urea nitrogen has proven a useful winter nutrition indicator in deer. Winter serum urea nitrogen (SUN) levels in fawns on park lands where subsistence is primarily from native vegetation indicated animals with severe undernutrition. SUN levels in fawns where FI residents provide supplemental feeding, did not exhibit as extreme undernutrition. Carcass weights, kidney fat indices, and femur marrow fat further testified to the nutritional status of FI animals.

Winter mortality counts also were used to evaluate the physiological status of FI's deer population. A nearly three-fold increase in mortality over previous winters was observed during the winter following hurricane Gloria, indicating a recently stressed population. Post-hurricane mortality consisted entirely of older animals (>5 years of age) or fawns. In contrast, aerial census counts one year after Gloria showed a 30 percent increase in the deer population over the previous 2 years. Increased mortality rates stimulated reproduction and the total FI population rose to an even higher level.

Using dark-field microscopy, the Lyme disease spirochete (*Borrelia burgdorferi*) was found in 25 percent of all ticks collected from FI deer. This is within the range of tick infection rates reported in the literature. Despite the presence of infected ticks on deer, it is

## Superglue-tagged Stoneflies (Continued from page 3)

clearly identifiable to age class,  $n=188$ ) shows a breakdown of movements by size and sex.

### Results from 1988

Conditions were somewhat different in 1988. Fewer *Pteronarcys* were found so only 486 were tagged. Recapture success was greater however (44%). Movements were smaller and there were few long or fast upstream travelers. Average total moved was -5.7 m showing increased downstream travel and fewer active upstream movements. Absolute value of all movements with zeros deleted was 8.1 m. Fifty-eight percent went downstream, 30 percent showed no movement, and 12 percent moved upstream. Figure 2 shows movements by size and sex in 1988.

I am still analyzing the data from 1988, and don't yet know if the addition of food or stoneflies was significant. Even without the manipulation results, it is obvious that great detail is obtainable using tagged individual insects.

Experiments about resource limitation will provide important information about the quality of aquatic habitats. Each animal species perceives its world on a different spatial scale. Does the "fine grain" important to a stonefly occur over 2-3 rocks in a riffle, or over 2-3 km along the stream? When we learn the fineness of scale important to aquatic invertebrates, we will then

know how to manage stream habitat for biotic diversity. We will also have better understanding of effects caused by natural floods and man-caused flow regime alteration.

Freilich is a graduate student in the U/GA Dept. of Entomology.

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generally accepted that white-footed mice (*Peromyscus leucopus*) and not deer are the primary spirochete reservoir for infecting ticks. Serial blood samples collected during the winter months showed fluctuating antibody titers to the spirochete. Although still uncertain, the change in titer levels may be attributed to the continual exposure of deer to infected, feeding adult ticks.

It is well known, however, that white-tailed deer are the primary host for the adult stage of the northern deer tick. The role of deer in the ecology of Lyme disease is ill-defined but appears to involve maintenance of tick populations. Recent evidence has shown that elimination of an entire deer population from an island off Massachusetts reduced larval and nymphal deer tick numbers. The evidence is less than convincing however, that removal of deer will eradicate this disease. Despite complete host removal, adult deer tick populations were not lowered. A varied host range for deer ticks and little transovarial transmission of the spirochete is indicative of species involvement other than deer in maintaining the disease cycle.

Nearly 70 percent of all live-trapped deer exhibited elevated antibody titers to *B. burgdorferi* as determined by indirect immunofluorescence (IF). Both IF and Enzyme Linked Immunosorbent Assays (ELISA) are well-established methods of detecting antibody levels to disease agents. An ELISA specifically for deer sera had not been previously reported in the literature and development of such an assay was completed as part of our study. A comparison of the two techniques for deer sera showed similar antibody detection rates.

Deer management is fast becoming a significant issue in many eastern parks. As long as Lyme disease is a public health concern and deer are in any way associated with the disease vector, the public outcry for deer management likely will continue.

Habitat continues to be fragmented by land development and deer populations are becoming increasingly confined to designated parks and reserves. Although dispersal opportunities are limited, contact with humans will increase as deer seek out all potential habitats. Increased feeding pressure on natural areas may ultimately redefine the vegetative component of such systems. Active, rather than passive management will be necessary. Depending on legislative restrictions imposed on various park areas, efficient, effective management programs for deer will require substantial funding sources.

At present, deer research in several eastern parks is ongoing or has been recently completed. As a result, a workshop in FY '89 is scheduled in May by the North Atlantic, Mid-Atlantic, and Southeast Regions to organize the issue of deer management. For one park at least, Fire Island, active deer management will pose a difficult question given the variety of land management uses in an isolated ecosystem. As the pressures of society continue to delimit our natural areas, active deer management is likely to become the rule rather than the exception.

O'Connell, Jr. is now Chief, Division of Science and Natural Resources, Acadia NP (formerly natural resource specialist at Fire Island); Sayre is Associate Professor of Wildlife Biology, Univ. of Massachusetts; Bosler is a Research Scientist, New York State Dept. of Health; Art is a Professor of Biology, Williams College.



Blood sampling from Fire Island deer for health indicators and Lyme disease antibody levels.



Live-trapped deer being examined for Lyme disease infected ticks.

## Tough Management Problems Demand Ecosystem Approach

A conceptual approach to managing change in ecosystems crossing natural and political boundaries is set forth in a just-published book, *Ecosystem Management for Parks and Wilderness*, edited by James K. Agee and Darryll R. Johnson. The need for cooperation among government agencies as well as across disciplines prompted the National Park Service, the U.S. Forest Service and the University of Washington College of Forest Resources to sponsor an ecosystem management workshop for scientists, planners, and managers. Out of this workshop, the book grew.

From the workshop's prioritization process, three needs emerged: a precise definition of management objectives for park and wilderness lands and how to integrate them with objectives for surrounding lands; more information about physical, biological, and social components of park and wilderness ecosystems from both sides of political boundaries; and key indicators of ecosystem condition as well as methods for evaluating

management effectiveness.

In addition to an introduction that outlines a direction for ecosystem management in the next critical decades, the individual contributors cover laws governing park and wilderness lands; paleological records that reveal the historic effects of climatic variations on vegetation change; succession and natural disturbances in relation to the problems of what can and should be preserved; managing ecosystems for large populations of vertebrates; the management of large carnivores; effects of air pollution; lake acidification; human ecology and environmental management; the role of economics; cooperation in ecosystem management; and management challenges in Yellowstone NP.

The 246-page book, with figures, tables, and glossary, is available for \$20.00 from the University of Washington Press, P.O. Box 50096, Seattle, WA 98145-5096.



# CAD Applications at Wind Cave NP

By Jim Nepstad

Wind Cave NP, located in the Black Hills of western South Dakota, is an intricate, multi-level maze of underground passages of incredible dimension. To date, explorers have mapped over 52 miles of these passages, making Wind Cave the seventh longest cave system in the world. All indications suggest that many more miles of cave await discovery. But Wind Cave is much more than just a collection of passageways hidden beneath the hills.

Contained within this maze is an astonishing variety of resources, ranging from items of historical or cultural interest, to magnificent examples of some of the world's rarest cave formations (or "speleothems," as they are more properly called). Woven into this is a tiny, highly specialized, and extremely fragile ecosystem. Managing so many resources with such a high level of susceptibility to human impact is difficult. Making proper management decisions invariably comes down to knowing precisely what resources are located in each area of the cave. For this reason, cave maps have always been invaluable tools for the cave manager.

Wind Cave has traditionally presented its mappers with nontraditional challenges. Perhaps the most daunting of these is the three dimensional maze nature of the cave itself. The entire known cave is contained below a surface area of less than 500 acres. Thus in many areas, several passages overlap at different elevations in the limestone. It is difficult to portray the three dimensional relationships of these passages on a two dimensional piece of paper. Resources found within the cave have normally been kept off of the map for fear of "cluttering it up," resulting in a map which lacks some of the most critical information concerning the cave. Thus, determining what resources may be found in any particular passage has meant pouring through reams of survey notes, trip reports, and inventory forms – a time consuming process.

## In Pursuit of a Better Cave Map

During 1985 and 1986, with the help of a magnetic induction device known as a "cave radio," work was carried out which eventually proved that the existing Master Map for Wind Cave was not accurate. Many rooms and passages on the map were shown several hundred feet from their true positions. Concerned that the map should more accurately portray the relationship between the cave and the overlying surface features and developments, the management at Wind Cave decided that a redrafting of the map was necessary.

The original plan had been to produce a typical ink on mylar drawing of the cave. Since declination changes had to be made in the survey data, and since radio located passages had to be constrained – thereby vastly complicating the problem of closing the hundreds of surveyed loops in the cave simultaneously – it was immediately apparent that a computer would be necessary.

Initially, the idea was to use the computer to reduce the survey data for the cave's 11,700 survey stations. The resulting coordinates could then be stored away and used to help produce the hand drawn map. But after researching the IBM and IBM compatibles software market, it seemed that we could take it one step further – we could also store the drawing itself (including passage outlines) in the computer with the use of computer-aided-design (CAD) software.

## An Introduction to CAD

Just as a word processor is used to manipulate words, sentences, and paragraphs, CAD software is designed to manipulate lines, arcs, circles, and the drawings which contain them. Anything which can be drawn by hand can also be drawn using CAD software. The ability to draw objects on individual "layers" (similar to transparent overlays on conventional drawings) is one of several features which make CAD drawings superior to their paper counterparts. For instance, the plans for a house can be contained in just one drawing, with separate layers for each floor, layers for wiring and plumbing, and even a layer for landscaping. These layers can be viewed one at a time or together in any combination. Once created, they can be plotted at any scale or orientation.

It was the above capabilities which initially attracted us to CAD. No longer did we have to worry about the map being unreadable in vertically complex sections of the cave. By placing each survey station on a layer based on its elevation, we could "turn off" layers in complex areas of the cave to zoom in on the area we were interested in. Layers could be created to portray surface topography, surface developments, and vegetation types overlying the cave, providing visual clues to the links between surface and subsurface worlds.

The software we chose for the redrafting of Wind Cave's map was AutoCAD, published by Autodesk, Inc. Primarily, this was because AutoCAD was (and continues to be) the recognized industry standard. Its huge user base ensures that the program will be constantly evolving. The program's "open architecture" provides programmers with an opportunity to develop add-on programs which complement the original. AutoCAD is extremely powerful "out of the box," but this feature extends its power significantly. A wealth of information is also available in the form of books, magazines, and user groups making it easier to learn some of the program's finer points.

## Methods

The first step in producing our digitized map of Wind Cave was to enter the survey data into a program which could analyze it. Since there are more than 11,700 stations in the cave, representing roughly 40,000 individual measurements, this was no small task. Approximately 600 hours were spent on this part of the project, the end result being a file which contained a unique set of coordinates for each station.

Once this was accomplished, a program was written to read in the coordinates from this list, placing them in an AutoCAD ".dxf" file, a file which directs AutoCAD to create a drawing on its own. This file instructed AutoCAD to draw a line between each survey station, and to draw a triangular symbol at the exact location of each station, along with the station's name. This provided the skeleton around which the map would be drawn.

A feature of this line plot is that it takes advantage of AutoCAD's 3D capabilities. The lines between stations are "three dimensional" in that they may be viewed from any possible angle. This provided us with an opportunity to view the profile of the cave for the first time. Other views are providing us with interesting clues into the cave's development by giving us insight into the structural and stratigraphic relationships of the passages.

Once this line plot has been produced, it is possible to add the passage outlines with the use of a digitizing

tablet. Passage outlines are drawn with pencil or ink around a line plot, then traced over with the digitizing tablet, which sends a stream of coordinates to the host computer to be stored away. Passage outlines are drawn on layers different from those that contain the line plot, enabling us to turn off the line plot for more artistically appealing maps. Layers are also created for passage features and contents, so that traditional cave maps may be plotted if desired.

## The Map Becomes a Database

Another important feature supported by AutoCAD and other CAD packages is "attributes." An attribute can be thought of as a tag that can be attached to a part of the drawing. This tag can contain a piece of information concerning that particular part of the drawing. For instance, in a drawing of a house, attributes could be assigned to the door and window symbols. These attributes could contain information concerning the type of door or window needed, its cost, its energy efficiency, and any other information which seems necessary. All of this can be kept invisible if desired.

In the drawing of a cave, attributes could be attached to survey stations. The information which could be stored with each station on a map would include the survey station's name, its X, Y, and Z coordinates, any speleothems present, items of historical and biological interest, information regarding the amount of water present, search and rescue information (rigging instructions, etc.), travel statistics, and any other bits of information which may be acquired in the future. In short, everything known about every survey station in the cave could be included on the map, ready to be accessed at the push of a button.

A cave much smaller than Wind Cave would work quite well with the above scenario. But the amount of information inventory trips are bringing in from the field would quite simply cripple the drawing by vastly slowing down the rate at which it generates on the computer screen. It was therefore decided to store inventory information in dBASE III+ files, with each database record corresponding to a survey station in the cave.

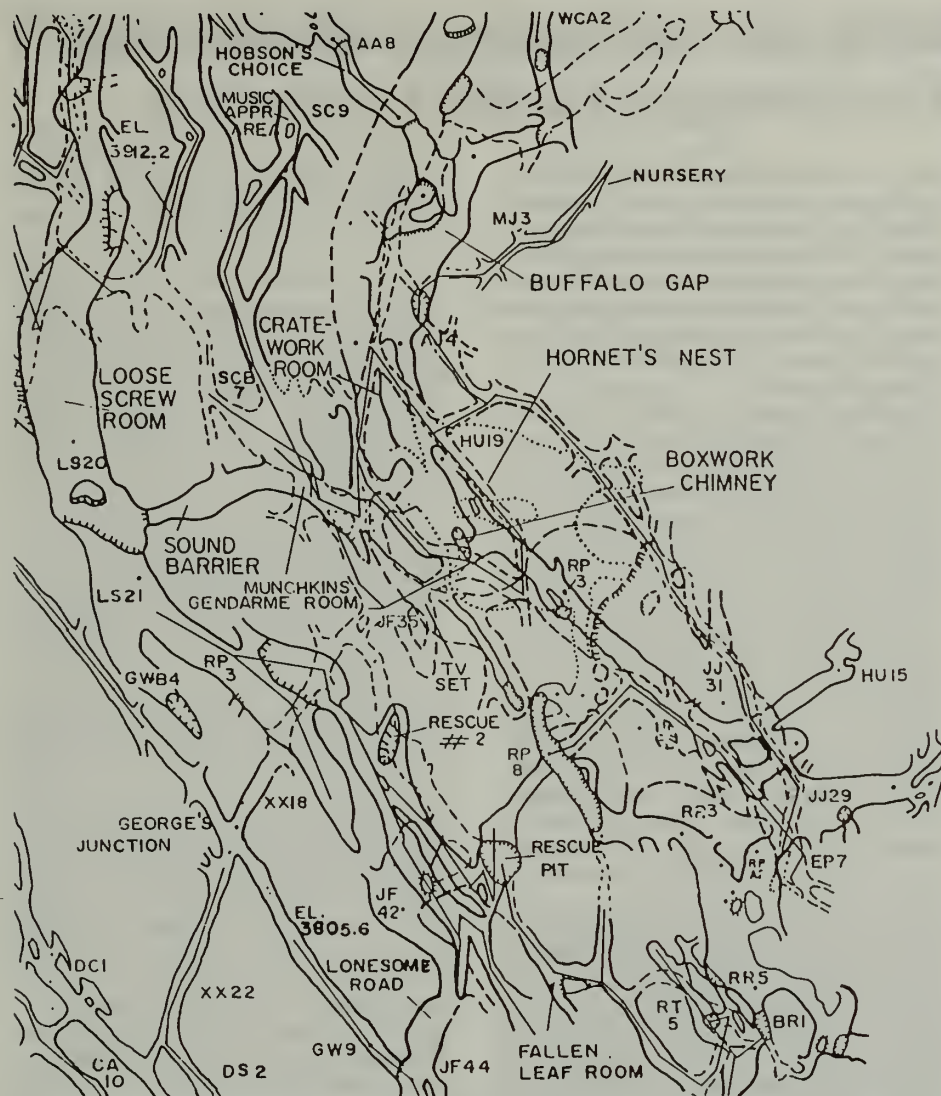
This required a little more creativity, since programs had to be written to interact between dBASE and AutoCAD. We can now search the dBASE files for any set of conditions, at the same time highlighting the survey stations on the AutoCAD map which satisfy those conditions. Even with the huge database and drawing files which Wind Cave generates, this process takes less than five minutes.

It is this important step that takes the digitized map beyond the realm of the traditional cave map. Traditional maps convey most of their information graphically, with little or no text. This is fine for a general overview of a cave. But what if you want to know where all the wet sections of a cave are? What if you want to see all occurrences of a particular speleothem at a particular elevation range? With a little programming, we have unleashed the real power of the digitized map.

## The Map as a Collection of Maps

The programs produced at Wind Cave help us mimic one of the greatest talents of a GIS, the ability to produce new maps based on the outcome of some kind of query. By manipulating the information stored in the dBASE files, it is possible to produce an almost infinite number of maps from the original. Cross referencing data from two or more fields will produce graphical representations of relationships only dreamed of in





A vertically complex section of Wind Cave. Large numbers of areas such as this resulted in a map which was difficult to read.

the past. What effects are surface developments having on the cave? Do all major aragonite occurrences occupy the same elevation? What fragile areas are experiencing the highest visitation? Maps which will contribute to answering these questions can be produced in very little time. Thus, instead of being limited to one map which attempts to show us everything at once, we have a collection of maps, which will show us practically anything we want to know about the cave.

#### Implications for Management

By allowing such a vast amount of information to interact with the map, digitized cave maps such as the one under construction at Wind Cave will be of tremendous value to cave managers in the future. The decision-making process will not only be quickened, but considerably enhanced.

It should be further noted that applications for AutoCAD at Wind Cave go far beyond the cave itself. Surface maps showing vegetation types, burn areas, cultural sites, and much more can be produced with little effort, enabling managers to learn more about relationships between these factors. The information age is just beginning at Wind Cave NP.

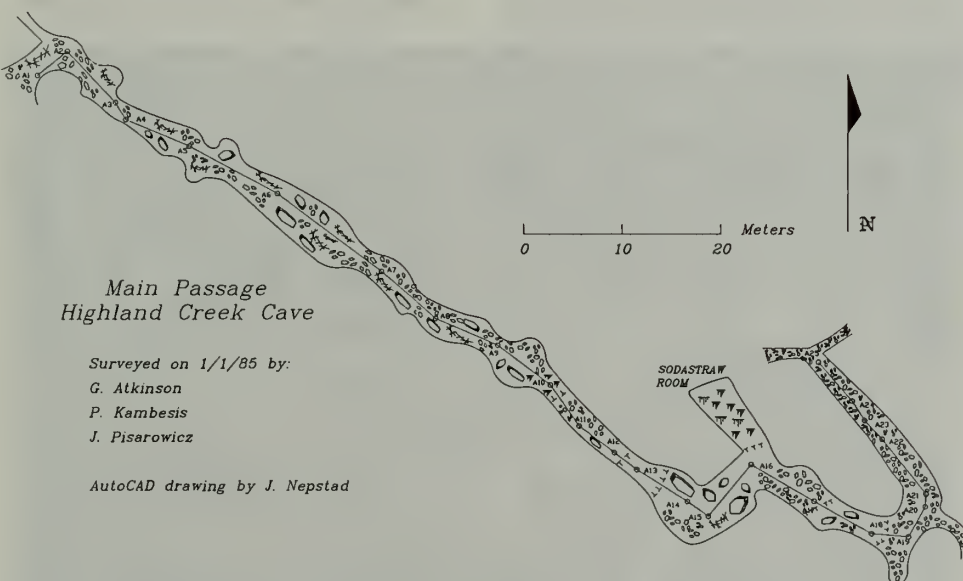
Nepstad is Park Ranger Naturalist at Wind Cave NP.

## Natural Resource Management Guide Nears Completion

NPS-77, the Natural Resource Management Guideline, will be distributed in late fall of this year, says Anne Frondorf, coordinator of the project. Its purpose is to give guidance on applying the recently revised NPS Management Policies as they relate to natural resource management. Written by more than 45 NPS authors, the Guideline is organized into five chapters: an introduction, Natural Resource Management, Resource Uses, Planning, and Program Administration and Management. Sections within the chapters address such topics as vegetation management, fishing, the resource management plan, and research administration. The detail of each section varies, depending partly on the amount of published guidance already available.

The Guideline was undertaken because of considerable field interest over the past several years in consolidating and elaborating upon existing guidance. Gene Hester, Associate Director for Natural Resources, initiated the project around March of 1988. He set up an editorial board consisting of a representative from each region and three from the Washington Office. Both scientists and resource managers were included. The board developed an outline and identified prospective authors.

Copies of the first draft were distributed in May to every park, the regional offices, and Washington Office divisions. Comments from the field and revisions by the editorial board will be incorporated to make the final version.



An example of a digitized cave map showing survey information, passage features, and passage contents, each on a different drawing layer. Layers can be turned on and off to attain the level of detail desired.



# Environmental Effects and Monitoring of Abandoned Drilling Muds: The Wrangell-St. Elias Approach

By Timothy E. Law

Who would think that within the largest U.S. national park there exist uncontained drilling muds with high concentrations of heavy metals? Wrangell-St. Elias National Park and Preserve, 13.2 million acres in southeast Alaska, inherited this reality when the park was established by Congress in December 1980, under the Alaska National Interests Lands Conservation Act (ANILCA, PL 96-487).

In 1984, a comprehensive inventory for waste materials was conducted on park lands, focusing on numerous abandoned mining claims, milling sites, and mineral and oil exploration locations. This is the story of just one such site, located in a remote area west of Yakutat Bay on the Gulf of Alaska, where approximately 83.5 tons of unused drilling muds, abandoned in 1962 by an oil exploration company, were found.

During the original operation, from the mid-50s to the early 60s, at least nine wells were drilled in the Dry Bay and Icy Bay areas, on the Malaspina Glacier forelands, and near the village of Yakutat. The Sudden Stream waste site lies on the Malaspina forelands in southeast Alaska, approximately 20 miles northwest of Yakutat village. The mud pile is about 0.5 miles inland, at the end of a revegetating air strip that was constructed from local gravels and top soil. The area is generally flat, less than 50 feet above sea level, and has a characteristic high water table (6 to 10 feet).

## Early Site History

It is believed that Colorado Oil and Gas Corp., which changed its name in 1976 to Derby Oil Co. out of Delaware, built and used the air strip as a staging area for drilling operations. About 3 to 5 acres of land were disturbed by the airstrip construction. Total area being affected by the *unused* drilling muds is still undetermined, but it appears that the majority of metals from the waste pile is confined to a radius of approximately 150 to 200 feet.

In the late summer of 1962, a well was drilled less than 150 feet from the mud pile to more than 12,000 feet in depth. The question remains – what happened to the *used* muds from this operation? A distinct possibility is that these muds, which may amount to a substantial volume and would contain high concentrations of heavy metals, were disposed of in the area around the well site and along the airstrip.

When the exploration ended, the *unused* muds were abandoned, stacked in their original heavy paper sacks, and housed in a plywood shelter. Over time, the shelter deteriorated and collapsed, exposing the muds to weathering and leaching. In a preliminary site inventory, five mud types were identified: Q-Broxin (16,000 lbs), Maccowate (43,200 lbs), Economy Gel (52,800 lbs), Hydrogel (68,800 lbs) and Arco (4,500 lbs).

Laboratory analysis showed the highest heavy metal concentrations were barium (Ba) and chromium (Cr). Of primary concern were the drilling muds Maccowate and Q-Broxin, which showed concentrations of 480,000 ppm (48%) barium and 2,000 ppm (2%) chromium by weight, respectively.

## Preliminary Investigations

Sampling and analysis of the soil and water were conducted to determine the extent of metals migration outward from the mud pile. Mobile forms of these met-

als can enter the surrounding environment primarily via two transport mechanisms, water leaching by precipitation and aerial transfer by wind. Initial results showed the presence of both barium and chromium in the soil and surface water within 150 feet of the mud pile. Ranges of metal concentrations in the water were 50 to 220 ug/l for barium and 50 to 230 ug/l for chromium; in the soil, 1,000 to 1,590 for barium and 1 to 66,700 ug/l for chromium.

The EPA and Alaska Department of Environmental Conservation (ADEC) standards for domestic water supplies are 50 ug/l for chromium and 1,000 ug/l for barium. EPA also indicates the limits for aquatic life are 100 ug/l (Cr) and 50,000 (Ba). Preliminary results thus showed that directly around the site there were concentrations of chromium in excess of applicable state and federal regulations for drinking water.

Background information and sampling results were reported to EPA and ADEC. In the summer of 1986, EPA made an onsite evaluation of the threat to the environment and to the general public. With completion of a preliminary assessment, EPA recommended that NPS should pursue cleanup activities and continue monitoring the site. Major findings showed a potential for metal transport into the groundwater, surface water, air, soil, flora, and fauna at the measured heavy metal levels. The possibility also exists for incorporation of metals into the food chain.

Under the current EPA hazardous ranking system, two factors are of top priority: the site's remoteness (i.e. immediate threat to a populated area) and the potential for contamination of a public drinking water source. Since this site is located a substantial distance from a nearby community and public drinking water source (about 20 miles), it was given a low hazard ranking by EPA and did not qualify for placement on the National Priorities List (NPL) for cleanup funding. However, EPA did submit a funding request for initial site cleanup to the Office of Management and Budget (OMB). This was rejected. The Wrangell-St. Elias NP staff obtained support from the Alaska Regional office for a sampling

program in the summers of 1987 and 1988 to identify the spread of barium and chromium.

## Sampling and Analysis

To gain full understanding of how the environment was being affected around the waste site and to design and implement a long term monitoring program, an expanded, multiple-phase sampling scheme, including water, soil, vegetation, and aquatic life was needed. The premise of the field work completed in the last two seasons was to document more concisely the degree of metal concentrations and the area being affected.

In summer 1987, 10 locations were established for sampling surface water in streams, lakes, and standing pools around the site and groundwater was collected from soil pits excavated to the water table. Within ~ 200 feet of the waste pile, metal concentrations ranged from 60 to 88,000 ug/l (Ba) and ~ 5.0-665 ug/l (Cr). Metals were spreading in all directions, however highest concentrations were noted in water samples collected about 90 to 100 feet downslope and in the direction of leachate flow away from the waste pile. Farther from the waste pile (~ 1800 feet), toward Sudden Stream, an outlet from Malaspina Lake, Ba and Cr levels dropped off to 130 ug/l and 20 ug/l respectively.

In summer 1988 a more intensive effort included sampling of water, soil, vegetation, and fish/mollusks around the waste site and in control sites. The intent was to obtain a broader spectrum of data that more accurately identified the extent of water and soil affected and for the first time included vegetation and aquatic life. Methods used for collection, preservation, and shipment of field samples followed USFWS procedures. Major findings were these:

(1) Metals are being leached onto the ground and into the surface water and soil directly around the site. These elevated concentrations, ~ 6 to 100 times background, are found primarily within a radius of 150 to 200 feet downslope and to the east of the waste pile. A substantial decrease occurs in metal concentrations



*Pile of unused drilling mud in a deteriorated condition, showing scattered debris and remains of the plywood shelter in which it was enclosed. (Photo by Timothy Law)*



# Research Suggests New Options For Old-Growth

By Jean Matthews

The idea of "setting aside" areas of old-growth Douglas-fir forests was joined by another option – the preservation of "many of the elements" of old-growth, when almost one thousand scientists and interested lay people met in Portland, Oregon, in March to attend a landmark symposium on old-growth forests in the Pacific Northwest.

The gathering, sponsored by the U.S. Forest Service and the University of Washington, heard results of nearly five years of research, conducted by the Old-Growth Douglas-fir Forests: Wildlife Communities and Habitat Relationships project. Jerry Franklin, recognized "dean of old-growth research" and chief plant ecologist at the USFS Olympia, Washington research lab, strongly challenged the notion that late-growth forests were biological deserts.

"Far from being the 'cellulose cemeteries' they have been called," Franklin said, "old-growth forests of the Pacific Northwest contain more organic material per acre than even the densest tropical rain forest –

material that recycles nutrients back into the soil if they are left to decay naturally."

The key word is "naturally."

Most Douglas-fir forests begin with fires that clear the land and open it to sunlight where new seedlings can germinate. Research on wildlife populations in never-logged forests suggests that so-called "natural" forests have more in common with each other, regardless of their age, than these "natural" forests have in common with logged and replanted "managed" forests. The latter show much lower biological diversity.

The northern spotted owl is the most-studied creature of the old-growth forest ecosystem but it is only one actor in the huge cast of characters that play out their drama under the forest canopy. This small brown bird with a white mottled breast nests only in naturally occurring cavities in deformed, living old-growth conifers with broken tops. Its preferred prey in Oregon is the northern flying squirrel (a canopy dweller) and the red tree vole (a burrower beneath rotting logs).

The spotted owl is the surrogate, or shorthand battle star, that stands for every environmental task being performed free of charge by natural old-growth forests. Years of focused research have shown that old-growth forests comb pollution out of the air with their long, needle-fingered crowns; their intricate web of life includes galleries of wood-eating insects that help

reduce downed wood to the basic constituents of new growth, and below ground fungi that feed the towering trees and are fed in return; their logs and snags provide dwelling places for insects, salamanders, small mammals and birds, and anchor soil on downhill slopes; their uneven canopies let in sunlight but keep out snow, providing winter forage for deer and elk; their fallen logs are vital to the health of forest streams and when the logs drift down to the estuaries they become resting and foraging perches for egrets, bald eagles, and great blue herons.

The enormous amount of research generated by the \$2 million study is appearing in digest form in a variety of popular publications, slanted to a wide range of reader interests. One piece, that sets a general scientific findings in the political and economic framework (Sample: a truck bumper strip that reads "Save a logger – kill a spotted owl") appears in the April 1989 issue of *Research News*. The author, William Booth, points out that the owl is largely the symbol of the greater fight to save the old-growth forests. At stake is 374,000 acres of national forest proposed for set-aside. A federal judge in Seattle will decide in June. This set-aside would reduce available timber supply by 5 percent, would result in a calculated loss of about 3000 jobs, and would support about 1300 pairs of owls.

As Booth adds, "For how long, no one is certain."

## Abandoned Mud (Continued)

from ground surface to a two-foot depth in the soil profile.

(2) Significantly elevated concentrations of Ba and Cr were found in the mud and water samples collected from a small pond on the north edge of the airstrip, several hundred feet east of the mud pile ... possibly due to leachate flow from the waste site or from used drilling muds disposed of in that area.

(3) All vegetation samples from the site showed levels of Ba and Cr higher than background concentrations. There was no correlation between distance from the site up to 75 feet and metal concentrations in the plants. Also, there was no distinction between metals incorporated in the plant tissues and metals present on the plants.

(4) Small fish taken within 200 feet of the waste pile (i.e. sticklebacks) showed elevated levels of Ba (9.1 ug/g). Fish collected in outlet rivers from Malaspina Lake, about 0.5 to 0.75 miles from the waste site, showed Ba and Cr levels consistent with control samples.

(5) Mollusks (fresh water mussels) collected in a lake about 250 feet from the waste pile showed Ba concentrations of 120 ug/g in the tissues. More mollusk samples at control sites need analysis for comparison.

Results clearly indicate that Ba and Cr are affecting the water, soil, vegetation, and some aquatic life in the area around the waste pile. However, except for the pond which is more than 500 feet away, the affected area appears to be confined to within about 250 feet of the waste site.

As per EPA recommendations, Wrangell-St. Elias NP&P will continue monitoring and pursue cleanup of the waste site. Additional sampling and analysis will enable us to map more precisely the areas affected and any other sources of contamination (i.e. used drilling mud).

Development of a long term groundwater monitoring program, including installation of monitoring wells and collection and analysis of groundwater samples, will be followed by preparation of a feasibility plan for alternative cleanup options. Once a specific option emerges, detailed specs and a site safety plan will be drafted and funding will be sought.

Law is a Hazardous Waste Technician with Wrangell-St. Elias NP&P.

## letters

Oh what thanks I owe *Park Science*! It just gets better and better and it was very good to begin with. I love it.

As I looked at the cover photograph and thought about the editorial (Spring 1989) I was reminded of a couple of lines from *Nature's Economy: A History of Ecological Ideas* by historian Donald Worster. "The idea that nature is orderly, that its order is rational and effective, that it is for the most part a stable, self-equilibrating order, is the most precious idea modern science has given us. I would much rather live in a society where that idea is taken seriously than where it is not." I wish we took it more seriously than we do; wonder whether we will.

While I can't find the source of the quote, Charles Lindbergh said, "The future of the human race will depend on combining the cleverness of science with the wisdom of nature." There is much we have to discover about nature.

In a wonderful and wise collection of essays, *Altars of Unhewn Stone*, sustainable agriculturist Wes Jackson explores the tension between human cleverness and nature's wisdom. About the essays, Jackson writes that they "are an attempt to understand the requirements of a science to be pursued as though its original material is more important than the work of the scientists who are shaping that material."

Your Spring editorial asks us to "marvel at the intelligence expressed in this tiny world..." As I marvel, I think about a science based on stewardship.

Ed Hessler, Director

Minnesota Environmental Sciences Fdn., Inc.

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St. Paul, Minnesota 55114

I wanted to share some thoughts about the book *CHAOS: Making a New Science* (see Editorial this issue). Several times, lately, I have awakened in the night with the thought of a new area where the science of Chaos comes into play.

The idea of order without periodicity is intuitively what the Park Service has been preaching in many of its vegetative and wildlife management strategies. Hardly a field has not been impacted by the study of chaotic behavior.

A Los Alamos resident, Gottfried Mayer-Kress, is in high demand by the military for his assertion that nations can be described mathematically as non-linear systems, and minor perturbations (such as the deployment of a particular weapons system) could lead to something as drastic as nuclear war. His last paper, published this year in *Nature*, was entitled "Chaos in the International Arms Race," which led me to remember the Falkland Island war, where a cheap, hand-held shoulder-fired rocket shot down several sophisticated multimillion dollar Harrier aircrafts.

The implications for biologists that there is order without periodicity are profound. We have always known that little happenings may have staggering long-term effects but to realize that all systems ultimately oscillate around so called "strange attractors" is to find insight into plant succession, animal populations, and life itself.

The Heisenberg Uncertainty principle tells me that by the very act of measuring, I change the behavior of the subject. Einstein tells me that I can know either where I am or what my velocity is – but not both. Now Gleick tells me that I can predict, within limits, where I will be but not how I will get there.

Mind candy – isn't it yummy??!

Milford R. Fletcher, Ph.D.

Southwest Regional Chief Scientist



# Prestigious Commission Urges New NPS Vision

By David J. Simon

The Chairman of an independent commission charged with evaluating National Park research and resource management policies has proposed a new vision for the National Park System to safeguard this vital national and international legacy.

In a report entitled *National Parks: From Vignettes to a Global View*, this prestigious group called for "action on an unprecedented scale" to apply ecosystem management concepts to the parks, bring about a "quantum leap in both the quantity and quality of research" in the parks, achieve a higher degree of professionalization within the NPS, and adopt an expanded NPS educational mission to nurture "a conservation ethic among all segments of society, including those traditionally underrepresented in park constituencies, in order to lead the nation toward an environmentally sane future."

Stating that "a new beginning is now in order," Commission Chairman John Gordon, dean of Yale University's School of Forestry and Environmental Studies, presented the report to Paul Pritchard, president of the National Parks and Conservation Association, and Manuel Lujan, Jr., President Bush's new Secretary of the Interior.

Pritchard stated that "this report should be viewed on its own; not as a replacement for the Leopold Report, but as a statement carefully reassessing and reaffirming the value of park preservation and the integral role research, science, and scholarship play in that preeminent responsibility. Policy is only as sound as the knowledge on which it rests," Pritchard continued, "and effective communication of park purposes and values must be the ultimate goal. I fervently hope that

with the help of a President committed to science and education, together we can move the parks to higher ground."

The Commission reached key conclusions in the following areas:

1. **Ecosystem Management.** Preserving park resources must continue to be the most important task of the Park Service. The parks must be managed under ecosystem concepts that blend natural, cultural, and social sciences and allow natural processes to act, while recognizing that humans dramatically influence park ecosystems, and that both impacts and management transcend arbitrary political boundaries.

2. **Research.** A significant improvement of NPS research programs across all disciplines must be initiated. A Congressional charter for NPS research, a mandate other federal agencies such as the U.S. Forest Service already enjoy, should be enacted. For example, the Park Service has only about 75 field scientists and 46 park historians for its 354 units, and research comprises only about 2 percent of the NPS operating budget, compared to about 10 percent in other land management agencies with similar responsibilities.

3. **Professionalization.** The NPS should pursue long-term goals to raise the standards of park management for all employees. More manpower and expertise is needed within social science, historic architecture, ethnography, and numerous biological disciplines. As resource protection tasks grow more complicated and specialized, the NPS can no longer rely on generalist rangers for all its needs. Career ladders must be made available to resource managers

so they can rise within the hierarchy along with managers with backgrounds in law enforcement and other areas.

4. **Education.** The National Park System and Service have the capacity to impart conservation ethics to the American and world population, reach out to new constituencies, and explain the processes of environmental and cultural change whirling around modern society. Public resources such as the parks can only be preserved with widespread public concern and understanding. As the most popular federal agency and custodian of the nation's most hallowed places, the Park Service has a unique opportunity and responsibility to lead the nation toward environmental solvency and sanity.

Pritchard was optimistic that the report would initiate new discussion on the future role of science and resource protection in the NPS. "The Service cannot preserve park resources if it doesn't know what or how much it has," he said. "I look forward to an honest, dynamic debate whose singular purpose will be to chart the future course of America's greatest invention – its national parks."

The Commission was established by NPCA with the cooperation of NPS to reexamine issues raised in the 1963 Starker Leopold report. While NPCA provided staff and logistical support, the group deliberated independently. Its 17 members included nationally respected authorities from nearly every discipline and resource category of concern to the NPS. The report was released on March 19, 1989 at a one-day symposium on national park policy in Washington, DC.

Simon is Science Task Force liaison for the NPCA.

## NPS Responds to NPCA 'Global View' Report

By Napier Shelton

Because of the recent change in NPS leadership, it is too early to tell what effect the NPCA Commission's report, *From Vignettes to a Global View*, will have on NPS directions. Responses from former Director Mott and others suggest a trend of favorable reactions. People see the report as endorsing current programs while urging expanded efforts in certain areas.

It is recognized, however, that the latter would have a big price tag. Some of the major changes recommended are much increased educational activity beyond park boundaries, a legislative mandate and greatly increased funding for NPS research, and developing the ranger series (025) as a professional series to insure that park managers have a stronger background in resource management.

Mr. Mott's remarks at the March 19 symposium organized by NPCA for the Commission to present and discuss the report can be regarded as representative of the reactions of much of the NPS hierarchy. "Taken at the broadest level," Mott said, "I view the Commission's recommendations for education, research, ecosystem management, and professionalization as a strong endorsement of the direction the Park Service has been moving in recent years. While our progress may, perhaps, not have been as rapid or as great as the Commission might wish, it has not been insignificant and we are proud of the initiatives we have taken and the work we are doing within the funds available to us."

"All in all, I think we are generally in agreement with the Commission ... I would guess that probably our largest differences might center on the amount of additional resources (funds and people) we should put into

the activities the Commission stresses ... at a time when the government is operating at a substantial deficit ... we can't put a stop to all the other things we are doing in order to redirect our resources into the areas the Commission focused on ..."

John Dennis, acting chief of the science branch of the Washington Office Wildlife and Vegetation Division, probably reflects the views of many NPS scientists and resource managers when he says, "We need more park managers coming out of resource oriented career fields. Our future decision makers need a stronger background and understanding in resource management." But he sees increasing the focus of park managers on resources in contrast to visitors as involving a "major upheaval" within the Park Service.

The NPCA Commission report recommends that 35 percent of NPS research be autonomous from line management to ensure an independent and credible professional program. Dennis agrees with the concept that some portion of NPS research should be oriented more to park management philosophy and Servicewide policy concerns, but thinks that 10 to 15 percent might be a more appropriate proportion. Basic research, while not needing to have immediate application to management, "should be demonstrably related to multi-park and Servicewide management needs."

To some degree, the NPCA Commission chaired by John Gordon fulfilled the mission of the Blue Ribbon Panel called for in the Mott 12-Point Plan. But it was less specific in its guidance than the Panel was expected to be. The Task Directive drawn up for the proposed Blue Ribbon Panel asked questions such as: "How 'wild' and 'natural' can natural area parks be, and to what

extent must they be manipulated in the contemporary American landscape?" "Should 'featured' natural resources (e.g. grizzly bears, giant sequoias) be managed as ecosystem elements or as special resources deserving of protection in their own rights?" "At what level should NPS be conducting baseline inventories and monitoring resources?" "To what extent should NPS reflect present visitors' values?" The Gordon Commission did not directly address such specific questions.

The report has been sent to superintendents, regional directors, and the Washington Office directorate. Presumably it will have some influence on the direction the Service takes under Director Ridenour. One of the ideas in the new Director's April 17 (1989) paper, "Philosophical Thoughts on the National Park Service," suggests that he agrees with at least one of the expanded roles for the Park Service – in education – as propounded in the Gordon Commission report. Ridenour's thought No. 8 reads: "Just as the world has become a global economy, we are increasingly bound together in our environmental world. It is in our own self-interest that we show, by leadership and example, our strong commitment to environmental protection. We have the ability to influence global thinking on many important environmental issues."

The Gordon Commission report in essence urges the Park Service to take a more regional and global outlook. The Service welcomes this authoritative advice and will look for means to carry out many of the recommendations.

Shelton is a science and technology writer with the NPS Washington office.



# Promoting Partnerships: The New NPS Challenge

By Sarah G. Bishop

*Editor's Note: Dr. Bishop is president of Partners in Parks, a non-profit organization that brings talented people to National Parks to work in partnership on projects of national significance. She was a member of the Commission which reviewed NPS research and resource management policy and signed the report, National Parks: From Vignettes to a Global View.*

After nearly a year of information gathering and deliberation, a Commission made up of 17 people from a diversity of backgrounds reported its findings in *National Parks: From Vignettes to a Global Vision*. What began as a review of the 25 year old "Leopold Report" ended as a confirmation of the basic National Park Service mission, with some added goals in research and education.

A major theme of the report is the need for parks to reach beyond their borders, both for assistance in meeting objectives and for building public understanding and support.

Perhaps the NPS's most far reaching partnership option is to join other federal agencies in the U.S. program of global change research. Government agencies in concert with others seek to establish a system to monitor and study the processes that cause change and to develop predictive models. All this effort will be meaningless if we lack the baseline knowledge of our biosphere and geosphere against which to measure change.

For terrestrial baseline research we need places that have been least disturbed by human activities as laboratories where research on global change can be accomplished. National Parks are those places. The Park Service must sit at the table with the agencies and organizations that will be conducting national research on global change and help write the research agenda that not only gives participating parks a fundamental resource inventory and sets up a monitoring system, but clearly defines an international need for research in parks. The best place to start would be in parks that are Biosphere Reserves and World Heritage Sites.

The Interagency Committee on Earth Sciences and the National Academy of Sciences Committee on Global Change will be developing detailed research plans in 1989. The Park Service must take this opportunity to become a player in global change by offering its lands as the best available sites for establishing baselines. The Service's reward will be a giant step forward in meeting its inventory and monitoring goals as well as developing a great deal of information, useful both for managing the parks and for developing comprehensive education programs.

Participating in global change research is just one aspect of working in partnership with others. Partnership opportunities exist for every national park. A number of in-place collaborative projects can and should be replicated.

One such partnership exists at Hawaii Volcanoes NP between the park and the US Geological Survey. The USGS maintains in the park a volcano observatory which the Park Service built for USGS. In exchange, the USGS has developed and helps the park maintain an exceptional interpretation center which informs visi-

tors of geological activity in the park, past, present and future.

At Shenandoah NP, several federal agencies are supporting research on topics ranging from controlling the spread of gypsy moths to measuring and determining the sources of acid precipitation. The park also provides logistical support for a number of independent researchers.

Another set of remarkable partnerships may be found at Golden Gate NRA. There the Fort Mason Center, the Golden Gate National Park Association and others sponsor hundreds of activities each month. So many volunteers are involved that almost everyone on the park staff is engaged in managing volunteer activities.

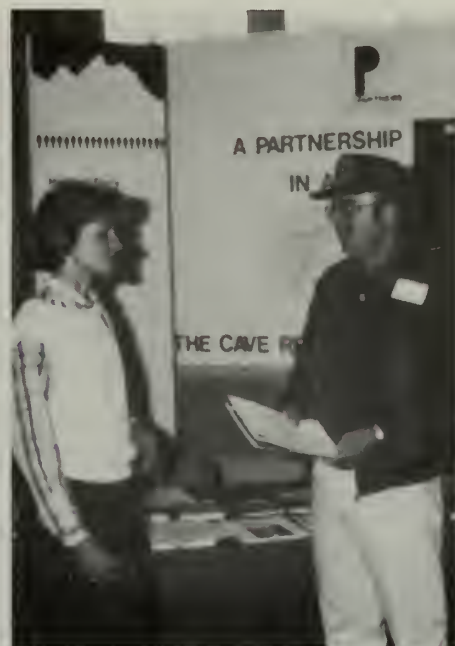
The Cave Research Foundation works in partnership with Mammoth Cave, Carlsbad Caverns, Guadalupe Mountains, Sequoia and Kings Canyon NPs, and several other NPS units surveying and conducting or supporting research on caves. This 30 year partnership has served both institutions well and has been cited by former NPS Director Mott as the model for melding NPS efforts with the work of private sector organizations.

Friends of Independence is a shining example of how a volunteer organization with highly skilled individuals can work collegially with a park. Friends are thoroughly integrated into the interpretation programs of the park, extending the park educational efforts far beyond what might be expected of a small staff. The Friends also have been invaluable in helping acquire historical objects for the park's collection.

A newly created non-profit organization, Partners in Parks, is dedicated to establishing partnerships that are technical or scientific in nature. The organization helps interested individuals and organizations gain access to national parks for the purpose of working on projects of national significance. It also helps national park managers accomplish major park goals and objectives. Partners' primary goal is to establish cooperative ventures between national park managers and private sector individuals and organizations working *pro bono* on their interests as well as on major park objectives. Where there are common goals and mutual interests, partnerships can thrive.

If national parks are to survive or better, thrive, they must have a knowledgeable, committed constituency. Partnerships can build public understanding and commitment to parks. Park managers who look outward will find partners who will join with them in protecting and preserving the treasures that are our heritage.

Each park must identify the community of which it is a part. The community may be as large as a region of one or more states, or as small as the nearest towns.



*Sarah Bishop discusses Partners in Parks with Organ Pipe Cactus National Monument Supt. Harold Smith at the Superintendents' Conference at Grand Teton NP in May 1989.*

Park managers who encourage community participation in park planning, development and implementation of programs and other activities will find willing partners.

In 1916 the people established the National Park Service and told its managers to be good stewards. The managers were in charge. The people did not have to pay attention; they were content then simply to visit from time to time these parks that were far from the every day world.

Now the every day world is encroaching on the parks. We visit in huge numbers, often concentrating our impact on small areas. Long distance threats such as acid rain and short distance threats such as subdivisions on park boundaries and upstream pollution force us to change the charge to the Park Service. We must all take responsibility for parks now.

If national parks are to thrive, they need knowledgeable, committed supporters. The partnership route offers the best hope for preservation of our cultural and natural heritage as embodied in the National Park System.

*Bishop holds a doctorate in education and directs Partners in Parks from 1855 Quarley Place, Henderson, NV 89014; (702) 454-5542.*



# Developments and Directions

The first NPS GIS Users' Workshop in Luray, Virginia, in October (*Park Science*, Vol. 9, No. 3, Spring 1989) provided us in the Geographic Information Systems Division with valuable feedback on the direction of the Service's GIS program. One of the chief messages delivered was the need for integrated software, ease of usability, and hardware uniformity and independence. Additional discussions with many of you since then have confirmed this message and caused us to make several decisions that will significantly affect the Park Service GIS program over the next few years.

## SAGIS and GRASS

We have decided to move away from SAGIS and to adopt GRASS as the sole GIS software used and supported by the GIS Division. Accordingly, we have entered into an agreement with the U.S. Army Corps of Engineers, the developers of the GRASS family of GIS software, to enhance GRASS to include certain vector capabilities now present in SAGIS. This work will take one to two years.

We are discontinuing the development of SAGIS and moving toward a single software system that possesses the capabilities now present only in the combination of the two systems. *We will continue to support SAGIS, including training, for as long as Park Service users require*, but all development work, except for meeting several immediate commitments, will cease.

Among numerous reasons for this decision are: our inability to develop and support two quite dissimilar software systems; the inefficiency and inconvenience of using two software systems with different file systems; elimination of the different hardware requirements for SAGIS and GRASS; the capability, through GRASS, to take advantage of contemporary hardware (specifically, the bit-mapped (UNIX) workstation) and software (e.g., X-Windows); the need for significant improvements in SAGIS's user interface and documentation; and the presence of image processing and raster-display capabilities not present in SAGIS.

If users need the vector editing, analytical, and pen plotting capabilities of SAGIS, they may continue to use it, in conjunction with GRASS, until GRASS possesses the needed capabilities (one to two years). Note to Opus Systems users: GRASS 2.0 is up and running on the Opus boards; we anticipate putting GRASS 3.0 on them by this fall.

## GRASS Training

We encourage users to take GRASS training at their

earliest convenience. The GIS Division will not, at least initially, offer such training, which must be procured from private vendors.

## SAGIS Training

*We will give SAGIS training, only if users indicate a need. In the absence of an expression of interest, we will not schedule any more SAGIS training.*

## SAGIS Menu

Peter Strong has developed a menu interface for SAGIS. It allows users to access SAGIS modules and perform certain operations entirely from a series of menus. It is running on the Opus Systems and Sun hardware; users may request the software, if they like. The menu system could also be installed on Mass-comp systems. Please let Peter Strong (303-969-2871, FTS-327-2871) know of your interest.

## SAGIS Documentation

New documentation for SAGIS's display module (CALPLOT) is available. Please advise if you want a copy.

## NPS GIS Users' Workshop

Many of you have asked about the next Servicewide GIS workshop. We intend to skip 1989 in favor of holding the gathering in conjunction with an international conference on the use of GIS technology in parks and protected areas. Baltimore, in November of 1990, is scheduled as the place and time of the event. I will be the program chairman. Please plan accordingly.

## GIS Coordinators' Meeting

Several GIS coordinators have suggested meeting to discuss the Servicewide GIS program. This meeting would be in lieu of a FY'89 Servicewide workshop. Please contact Phil Wondra to establish a time and place for the meeting.

## GIS Peripherals Contracts

The DOI GIS peripherals contracts, which allow you to purchase a UNIX workstation, digitizing tablet, pen plotter, and ink jet plotter, are still in place. *New procedures make it possible for you to purchase these items through your procurement officer in the park or Region, without going through WASO.*

## Digitizing and Scanning Contracts

The NPS has two contracts in place for digitizing and scanning, respectively, of maps. The contracts also have provisions for performing data transfer and building textual data bases. Call me for details.

Harvey Fleet, Chief

Branch of Digital Cartography  
303-969-2593, FTS-327-2593

## More From Harvey Fleet

The winter 1989 Information Crossfile contained a reference to an article on artificial intelligence (AI) and, particularly, intelligent geographic information systems (IGIS). On a recommendation from our editor I sought out and read the article. Here is my reaction:

IGISs differ from conventional GISs in two important ways. They contain information about the relations among the various elements, or layers, or themes, in the GIS data base, and they contain information about how to use this information to solve various kinds of (resource) problems. Conventional GISs, by contrast, contain information only about the internal properties of the data they contain, such as their location, status, ownership, condition, importance, and so forth. Human (expert) operators must understand both the relation among the data themes and how to use the system.

IGISs would appear to have wonderful promise for enhancing the utility of GIS technology to park management. One can easily fantasize about a resource manager sitting down at the keyboard (or microphone!) and typing in (or speaking) some simple, plain English questions or commands, like "Derive a gypsy moth hazard rating map" (as in Shenandoah), or "Generate a fire behavior model and show me all resources-at-risk" (as in Yosemite or Yellowstone), or "Generate a model of geomorphological change" (as in Gulf Islands or Cape Cod), or "Create a landscape restoration model" (as in Saratoga). The system would go out and find the right data elements, interact them correctly with another (according to built-in rules), and generate appropriate output. Viola! Instant, effortless results!

**Sadly, reality intervenes.** One must crawl before one can walk, let alone run. We are struggling mightily with our first steps – to establish credible, accurate data bases, to install useful – and usable – hardware and software, and to find people to dedicate to operating the technology. *We have much work to do before we can devote our energies to building AI rules into our systems.* Perhaps one not-too-distant day, after these prerequisites have been met, we will have software to custom-tailor IGIS's to individual parks. In this scenario, each park would go through a fairly detailed (one-time) installation procedure building specific rules that apply to its own unique situations.

There is no doubt that expert systems can certainly help users. They will never, however, replace the need for onsite systems administrators responsible for the care and feeding of the hardware, software, and data bases. They will also never be substitutes for knowledgeable and skilled resource managers, who understand resources and the relationships among them, and who know how to ask the right questions.

## 'Giant Green Wave' Sweeping Western Europe

An LA Times-Washington Post news dispatch out of Rome in May describes "an unprecedented tide of environmental concern sweeping Western Europe," and suggests that Europeans are looking at the United States and "determined to learn from our mistakes."

Queen Beatrix of the Netherlands is quoted as saying "The Earth is slowly dying, and the inconceivable – the end of life itself – is actually becoming conceivable."

Margaret Thatcher of England, speaking to 180 scientists, doctors, diplomats, and senior government officials, warned that people may "unwittingly have begun a massive experiment with the system of the planet

itself." She cited specifically the greenhouse effect, the shrinking ozone layer, and acid rain.

Politicians across the continent are playing to the growing national preoccupation with environmental concerns which, according to an American senior consultant at the Organization for Economic Cooperation and Development in Paris, "hasn't hit the top yet."

What the Rome correspondent, William D. Montalbano, refers to as "the giant green wave" is a product of "better scientific monitoring and better communications that have underscored Europe's own ecological horrors to its people." Italy's deputy prime minister has

called environment "the one issue that can unite us now" in the face of a threat that knows no political boundaries, to wit:

"Acid rain spawned in England kills forests in West Germany and Scandinavia. Eighteen nations on three continents help pollute the Mediterranean Basin. Chemicals spilled into the Rhine in Switzerland kill fish in the Netherlands. Mercury contamination from a plant in West Germany fouls drinking water behind barbed wire fences 20 miles away in East Germany."



# Crater Lake Theories Face Peer Review

A peer review panel of seven scientists is mulling the evidence for and against the proposition that hydrothermal features are responsible for some mysterious features at the bottom of Crater Lake.

What is beyond dispute is the evidence uncovered by Jack Dymond and Robert W. Collier, faculty members of the Oregon State University College of Oceanography, who have been exploring the lake for the past several summers. They have found excess heat, communities of bacteria, helium 3, arsenic, sodium, potassium, and a variety of other dissolved elements and gases.

The peer review panel met at OSU early in May and heard evidence for two opposing theories for the bacterial mats, higher temperatures, and above-normal concentrations of various chemicals: Hydrothermal springs feeding into the lake from the depths, and an alternative hypothesis that warm ground water from the caldera rim could be seeping into the lake's south basin by way of a landslide area known as the Chaski Slide.

Charles R. Goldman, professor of environmental studies at UCal/Davis and chairman of the peer review panel, called the issue of "hot or cold springs" one that is not "totally resolvable without additional information."

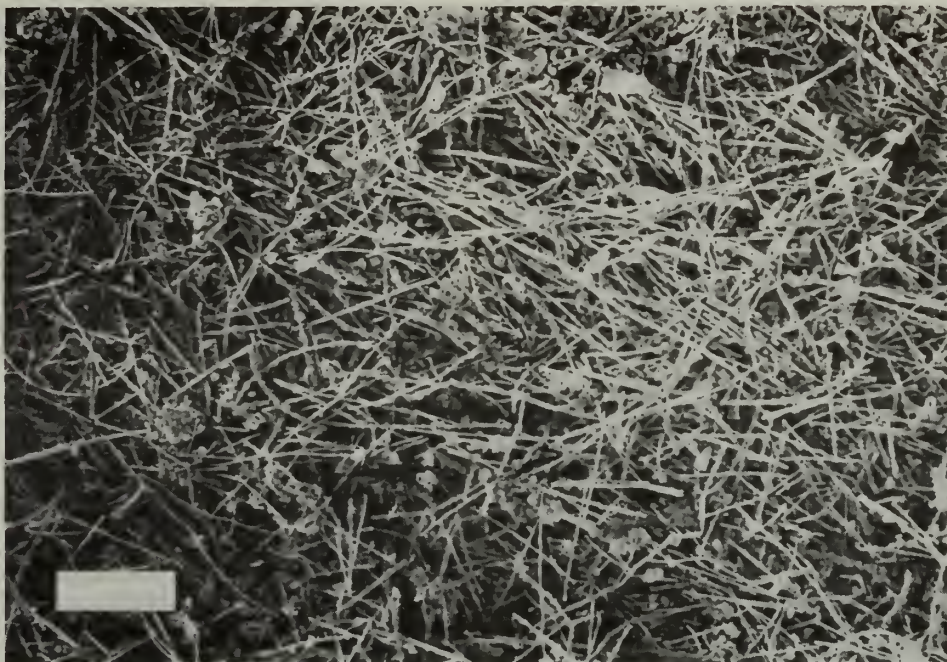
That information could be forthcoming at the end of this summer, when Collier and Dymond will have completed their third and final year of lake exploration for the National Park Service.

Deadline for an interim report by the peer review panel to the U.S. Congress was extended to June 30, 1989. According to Dr. Goldman, the panel will make "a number of suggestions" including advising better integration of other aspects of the NPS limnological study program with the particular kinds of investigations of thermal properties of the lake done by Dymond and Collier.

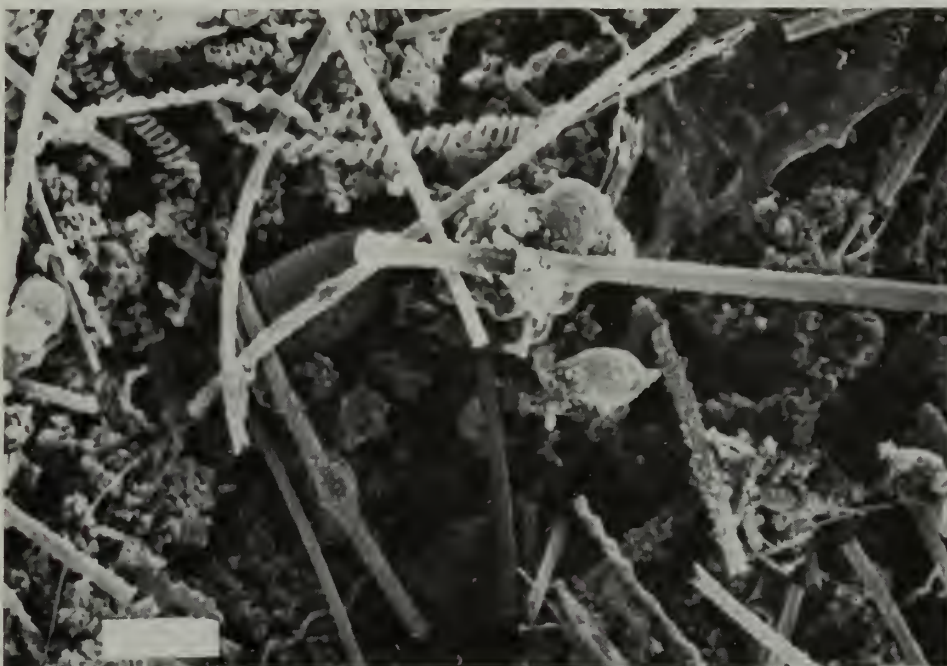
Of particular interest to Crater Lake NP visitors will be interpretation of the intricacies of the bacterial mats found deep in the lake by way of the submersible Deep Rover. Collier and Dymond will be exploring in Deep Rover again this summer, but will use what they hope will prove a more satisfactory navigational system than the one they used in 1988. The bacteria, identified as of the genera *Gallionella* and *Leptothrix*, can occur in areas fed either by cold or thermal springs.

The peer review panel, charged with evaluating and coming to some conclusions about the evidence for and/or against thermal features in the lake, consists of the following members in addition to Dr. Goldman:

Ken H. Nealson, professor of biological sciences at the Center for Great Lakes Studies, University of Wisconsin, Milwaukee; Joris M. Gieskes, professor of marine chemistry at the Scripps Institution of Oceanography, La Jolla, Calif.; David D. Blackwell, professor of geological sciences, Southern Methodist University, Dallas, Tex.; James McClain, associate professor of geology at UCal/Davis; Ivan Barnes, a geochemist with the U.S. Geological Survey, Portland, Ore., and Jorg Imberger, professor of civil engineering, University of Western Australia, Perth.



**A low-power scanning electron micrograph** of the bacterial mat found deep in Crater Lake during 1988 summer research. Tentative identification indicates these forms are iron-oxidizing sheath-forming bacteria of the genera *Gallionella* and *Leptothrix*. Oregon State University photo



**A high-power micrograph** of the bacterial mat shows the *Gallionella* as twisted sheathlike forms; the *Leptothrix* as straight sheaths. The ribbed dome-like form in the center is thought to be a protozoa, and could be feeding on the bacteria. The tube-like form with a blunt end at center-right is part of a diatom. Oregon State University photo

## Biosphere Reserve Symposium Proceedings Now Available

The 291-page Proceedings of the Symposium on Biosphere Reserves, part of the Fourth World Wilderness Congress meeting at Estes Park Center in Colorado, Sept. 11-18, 1987, is now available from either of the following addresses:

National Park Service, Wildlife and Vegetation Division, P.O. Box 37127, Washington, DC 20013-7127, or the U.S. MAB Secretariat, Department of State OES/ENR (MAB), Washington, DC 20520.

The document, edited by William P. Gregg, Jr., Stanley L. Krugman, and James D. Wood, Jr., consists

of 8 general concept papers, 4 papers on coastal-marine biosphere reserves, 7 papers on experience in developed countries, 8 papers describing experience in developing countries, and appendices that list biosphere reserves as of March 1988 and the World Wilderness Congress Resolution on Biosphere Reserves.

The general concept papers were authored by Jerry Franklin, Bill Gregg, Stan Krugman, Ariel Lugo, Ron Engel, James Thorsell, Jane Robertson Vernhes, and Bernd von Droste.



Two **biosphere reserve proposals** with great potential for accomplishment are progressing toward realization. At its April meeting, the U.S. Directorate for Biosphere Reserves recommended the nomination of the Kentucky Cavelands BR (Mammoth Cave NP) and the Tennessee/Cumberland Valleys BR. Approval by the U.S. MAB National Committee, the area administrators, and the international MAB Bureau is still needed.

Kentucky Cavelands BR would consist of Mammoth Cave NP as a core and the adjacent 62,000-hectare groundwater recharge zone as a transition area, or zone of cooperation. Superintendent Dave Mihalic points out that 20 percent of the world's land areas are underlain by karst terranes such as Mammoth Cave's, and that as a biosphere reserve this area could serve as a model for sound environmental management of other such lands. This is an unusually clear example of mutual dependence between park and region: the park attracts tourists to the region and the region must farm and handle sewage in ways that maintain quality of the groundwater that the park's cave life depends on. Cooperation between the park and local communities already has produced an agreement to build a regional sewage system. Public awareness programs are underway, and a study of farm fertilizer practices to prevent groundwater pollution has been proposed.

The Tennessee/Cumberland Valleys BR in western Kentucky and Tennessee would consist of the 170,000-acre Land Between the Lakes (TVA) and two nearby national wildlife refuges as satellites: Cross Creeks and Tennessee. No NPS area is included. The 6,648-acre core area would consist of four watersheds, 33 small ecology study areas, and a number of old-growth stands in Land Between the Lakes (LBL); the rest would constitute a buffer zone. Most of the LBL is intensively managed for recreation, timber production, and wildlife. Established as a national demonstration area in 1963 and now boasting a strong environmental education program, the LBL, with the two refuges, promises to become even more valuable to the region and the world as a biosphere reserve.

The **Lake Champlain Basin-Adirondack BR** in New York and Vermont was approved by the MAB Bureau in April. It becomes the fourth largest biosphere reserve in the world. Dedication ceremonies for the **Central California Coast BR** will be held in San Francisco on August 11. Interest in the new reserve runs high in that environmentally aware region, and many dignitaries are expected to attend.

A **draft action plan** for the U.S. biosphere reserve program is due in July. It will assess the program to date, refine the BR selection process, set priorities for conservation, research, and education programs in biosphere reserves, and recommend actions for using BR's in solving regional and global problems. It will stress that the program's mission in essence is to find ways to bring about integrated development and adjust to global and regional change while still conserving genetic resources. The action plan also will discuss creation of a U.S. Biosphere Reserve Report Series – a system for publishing any report on the BR research program of general interest to the biosphere reserve constituency.

Two important **meetings** on biosphere reserves are coming up in August. An NPS workshop on the role of biosphere reserves in addressing global change

In a stern, well-documented recital of global trends toward planetary catastrophe, Bill Brown of Denali National Park set forth for the recent George Wright Science in the Parks conference in Tucson the proposed Beringian international heritage park and its potential for "meshing the respective strengths (of the US and the USSR) in new syntheses for mutual benefit."

issues will take place August 1-3 at the University of Tennessee in Knoxville. And on August 8 and 9 a symposium followed by a workshop on developing an action plan for coastal barrier biosphere reserves will be held during the AIBS meetings in Toronto.

The **Proceedings of the Symposium on Biosphere Reserves**, containing 27 papers delivered at the September 14-17, 1987 meeting in Estes Park, CO, can be obtained from Bill Gregg, Wildlife and Vegetation Division, Washington Office (202-343-8122). The papers address general concepts, coastal-marine biosphere reserves, and experience with biosphere reserves in developed and developing countries. They present a rich, thoughtful picture of the evolving biosphere reserve program.

Napier Shelton  
NPS Washington Office

## MAB 'Language' Proposed

The two languages of the biosphere reserve literature – "the language of resource management" and "the language of community" – are explored by Ron Engel, professor of social ethics at Meadville Theological School of Lombard College, in the *Proceedings* of the symposium on biosphere reserves held in September 1987 as part of the 4th World Wilderness Congress.

Engel further contrasts the two languages as "the language of management" vs. "the language of participation," and proposes that the latter is the more appropriate as "the morally requisite modality for intervention in natural and cultural systems."

Engel proposes that "to make participation rather than management the fundamental theme of Man and the Biosphere requires the development of new forms of interdisciplinary research and development that are holistic and community-regarding." A plausible argument can be made, he suggests, "that it is the moral language of community that most authentically expresses the symbolism and ethics of the biosphere reserve concept. Approached through the moral language of community, one of the basic symbols of the biosphere reserve concept – global evolution – becomes a mosaic of co-evolving, self-governing communities consisting of diverse forms of life with intricately balanced, interdependent parts and processes."

(See page 13 for how to obtain the *Proceedings*.)

# Brown Paper Describes Beringian Park Proposal

Brown, who authored *Islands of Hope* and currently is at work on a history of Denali NP, traced the history of science as a product of cumulative cultural knowledge – its theories generally applied "only in a context of cultural readiness."

One of those moments, he maintained, is presently upon us.

The two kinds of readiness necessary are ideological acceptance of a need to do something and technological capability to do it. The "something" at hand is nothing less than saving ourselves as a species, and the National Park System, with its wideflung natural and cultural treasures and its interpretive function in place and respected, is peculiarly situated to give public awareness an educated boost.

The ancient land-bridge connection that made Alaska a peninsula of Asia endures to this day, Brown said, in the fields of physical, biological, and anthropological sciences. Recognizing the joint interests of the two countries, the Beringian Heritage Project – adopted in a 1987 protocol following reciprocal visits that year by US and Soviet delegations, "would open the way for joint scientific research, actively sponsored by the benefiting nations."

Brown's entire paper will be carried in a forthcoming issue of *The George Wright FORUM*. His final paragraphs contain this vision:

"In broader perspective, the National Park System comprehends a spectrum of natural and cultural areas reaching from the tropics to the high arctic, from Maine to the Marianas. Unless the global trends warnings we have so far received prove unreal – an unlikely event – it is inevitable that our government, in concert with others, will be forced to mount Manhattan Project equivalents to stem the rising waters, control energy emissions, curb the poisons that Nature has finally refused to absorb.

"In pursuit of these massive tasks, key sites within our National Park System and allied conservation units, and in equivalent reserves of other nations, surely will function as monitoring, research, and experimental centers. They will record levels and changes, pinpoint sources, and provide the scientific knowledge that can translate into reform and restructuring of current destructive practices. In this international mosaic of sites, the national parks of the United States will be critical benchmarks, standards by which deviations from or recovery toward healthy environments can be measured.

"As steward of these natural laboratories and data bases, the National Park Service must begin now to prepare itself for a key leadership role in scientific and social affairs, nationally and internationally, based on the geographies of hope that it is privileged to manage.

"Given all this, and with regret that grim necessity is its cause, I yet believe that this institution may be on the brink of resuscitation. Lord knows we need it. We need a cause that will restore and requite the bruised idealism of this honorable Service. We need to be valued again in our own society. We've always measured that value by the service we could render. I believe we'll have the opportunity to render more service than we've ever rendered before."



# information crossfile

American scientists are slated to visit China and the Soviet Union this summer to search unexplored areas for natural enemies of destructive insects and weeds, according to an AP story by Mike Feinsilber released in March. The U.S. Department of Agriculture's R. Dean Plowman is quoted as saying, "We're raising the priority of making biocontrol a vital part of American food and fiber production."

Taiwanese-born pathologist Yank Shaw-Ming will go to Inner Mongolia in search of a fungus that can destroy the leafy spurge, an aggressive weed that drives grazing cattle and horses away from rangeland. Five DA scientists will work with Russian counterparts to find biological controls against the Russian wheat aphid (which appeared in Texas three years ago and has spread to 15 states) and against a number of other pests such as the Russian thistle and grasshoppers.

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David Reynolds, Natural Resource Specialist and NPS Office of International Affairs liaison to the Peace Corps, was in Tanzania May 14 to 20 to assist with an Environmental Education Workshop. Sixty-five participants met in the Mt. Meru Hotel in Arusha and spent six days studying the differences between the "European" and African ways of viewing nature, exploring various approaches to increase community participation in protection of the environment, and examining ways to encourage community involvement in planning and development of parks and protected areas.

Thirty of the participants were Peace Corps volunteers working in parks or on wildlife or environmental education assignments in 15 African countries. The other 35 were African park wardens, directors of parks and wildlife preserves, and university professors, representing the governments of the 15 countries.

Reynolds has promised *Park Science* a report of the workshop upon his return in June.

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Staff and wire reports in the *Oregonian* in May tell of a voracious immigrant that has invaded the Great Lakes, threatening to disrupt the food chain and wreak havoc with the area's fishing industry.

The carnivorous culprit is a half-inch-long water flea named *Bythotrephes*. An animal member of the plankton community, *Bythotrephes* eats a smaller type of water flea that is the chief food for the fry of small fish species that are in turn eaten by larger salmon and trout.

Scientists with NOAA in Ann Arbor, Mich., believe that *Bythotrephes* – a native of Northern European waters – hitched a ride into the lakes aboard foreign freighters that dump their water ballast before loading up with grain.

All of which brings to mind the less-than-immortal verse of Jonathan Swift, to wit: "So Nat'ralists observe a Flea/Hath smaller Flea that on them prey/And these have smaller Fleas that bite 'em/And so proceed ad infinitum."

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"Environment could lose out in the face of economic realities" is the headline on a major wrap-up article by

Larry B. Stammer, environmental writer for *The London Times* in May 1989. Environmental ministers and other delegates from 124 nations convened in London for a "Saving the Ozone Layer" conference and they heard Mostafa K. Tolba, executive director of the United Nations Environment Program warn:

"There is not a single nation or individual on Earth whose wellbeing is not finally dependent on its biological resources; its seas and rivers, grasslands, forests, soil and air. Unless all nations mount a massive and sustained effort into safeguarding their shared living resources, we would face a catastrophe on a scale rivaled only by nuclear war."

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The deep divisions between the developed nations and those still struggling to achieve developed status was mirrored in the words of Mexico's ecology minister, Patricio Chirinos: "What is needed is to design and implement an international program to provide technical and economic resources and provide alternative jobs for the farmers and growers whose survival now depends on wresting land from the forest."

Robert E. Grady, the White House's deputy director for natural resources, said that despite momentous economic and political problems, protecting the global environment has strong appeal: "The beautiful thing about it... is that it does so clearly cut across ideological lines. The issue is protecting the mutual inheritance of all of us and all those who follow."

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*Northwest Woodlands*, Winter/Spring 1989, carries an article by Jim Agee entitled "How does fire effect the forest's soils?" Agee, formerly an NPS/CPSU research biologist and unit leader at the University of Washington CPSU and now professor and chair at U/WA College of Forest Resources, separates fire effects on soil into three categories: physical, chemical, and biological. "The relative importance of each category," he states, "depends on site characteristics and the way fire is applied..."

Agee considers the appropriateness of pile burning and of broadcast burning, discusses the warning signs of severe impacts, the effects of fire on water repellency, nutrient boosting (in the short term) and sagging (a long-term possibility), and the biotic effects ("complex and not fully understood").

As for "making a difference" with fire, Agee generalizes: "Avoid hot fires whenever possible; burn when the soil is moist... maintain fuel moisture at as high a level as possible to achieve the objectives of the burn."

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The News and Comment section of *Science* (April 7, 1989), commenting on the Valdez oil spill, noted that "the potential disaster... was forecast in a 1972 Environmental Impact Statement; the bumbling response was not." *Science* writer Leslie Roberts, in the same issue, quotes Howard Sanders, a marine biologist and senior scientist emeritus at Woods Hole Oceanographic Institution and veteran of many oil spills. In addition to the massive short term mortality among seabirds, marine mammals and fish, there is the problem of the longer term effects of oil within the water column. These are "trickier to predict." Sanders suggests that as the oil coats particulate matter it will be ingested by zooplankton and then excreted. This "rain of fecal pellets," Sanders said, is a major route of oil to the bottom. As oil accumulates there, the benthos could become anaerobic, making it unfit for marine fauna and for some marine flora.

# revegetation notes

Resource management at Lake Mead NRA has been busy this spring with several revegetation projects. Cactus were replanted at locations where the need had been identified; cottonwoods and willow cuttings were planted in riparian areas, and 90 cattails and bullrush tubers were planted on Lake Mead coves.

The Cottonwood District of the NRA joined in the effort to restore native riparian vegetation communities, signing up volunteers to plant cottonwoods. In April, a troop of Girl Scouts became the first group to officially "Adopt a Cove" in the new reveg program. The girls will "keep an eye" on the trees they planted, watering and picking up litter.

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Roger Lewin, staff writer for *Science*, in the April 7, 1989 issue considers "How to Get Plants into the Conservationists' Ark." At a March meeting on the genetics and population biology of rare plants, held at the Missouri Botanic Garden and organized by the non-profit Center for Plant Conservation based in Jamaica Plain, Mass., conferees considered a survey showing that between now and the year 2000, some 680 plant species native to the U.S. probably will become extinct.

The best remedy for this impending tragedy, according to Washington University's Alan Templeton, is habitat preservation. But as a realist, Templeton acknowledges this is not an option – "at least not with current trends of urban and agricultural expansion and natural resources exploitation." His solution is the maintenance of endangered plant species in botanic gardens "as an interim measure," with the hope that ultimately such cultivated populations can be released back into preserved or restored habitats.

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The Winter 1988 issue of *Restoration and Management Notes* carries an account by Steve Glass of restoration at Denali HP and Biosphere Reserve where, "except for a few dandelions and pineapple weed (*Matricaria* sp.) around park headquarters building, there is little problem with exotics," according to park research ecologist Roseann Densmore.

Despite this optimistic opening statement, Densmore feels that the danger of invasive alien plants becoming entrenched at Denali is real. She cites the work of other government agencies that are testing and introducing exotics right and left for use in revegetating disturbed areas. Sweet clover (*Melilotus* sp.) already is found near the park and is moving slowly in its direction, she said.

The author next interviewed Resource Management Specialist John Dalle-Molle about the revegetation projects he had worked on at Mount Rainier before being transferred to Denali. Dalle-Molle described for Glass the evolution of NPS thinking in the area of revegetation projects. "It just makes sense," he said, "that if you are concerned with wild pigs you should be concerned with dandelions and bluegrass (if these are non-natives)."

Roberts concludes with the statement: "All agree that the rich ecosystem of Prince William Sound will eventually recover. The only question is when."

**Continued on page 16**



# Woodstorks Move in on Cumberland Island

By Susan P. Bratton

"Great Basin National Park: The Nation's Newest" is the title of a recent (February 1989) issue of *Notes on People, Parks and Forests*, a limited circulation publication of the NPS/CPSU at the OSU College of Forestry, Kristin Martinson and Marty Lee are co-authors of the well-researched article, which includes a historic look, the present and future resources outlook, and a detailed study of visitors, present and potential. Martinson and Lee will prepare the material for *Park Science* readers in the Fall 1989 issue.

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A bound copy of the abstracts from the 8th International Bear Conference held Feb. 20-25, 1989 in Victoria, BC, came to *Park Science* from Kate Roney, NPS Resource Management Specialist at Kotzebue, AK, together with a copy of the paper she and fellow RM Specialist Lee Ann Ayres, and two Alaska Fish and Game Department scientists, presented at the conference. The paper is on "Applications of mark-recapture techniques and radiotelemetry for estimating grizzly bear density in relation to mining development and human exploitation in Northwest Alaska."

*Proceedings of the 8th Conference* will be published at a so-far undetermined date. Past *Proceedings* are available from Michael R. Pelton, Dept. of Forestry, Wildlife & Fisheries, U/Tenn., Knoxville, TN 37901. Costs for the 6th and 7th *Proceedings* are \$30 and \$35 respectively.

Roney was able to attend the conference because of a grant from the Horace Albright Employee Development Fund. She is preparing an article for the *Park Science* Fall issue based on the conference, where more than 200 people from 10 countries heard 765 papers.

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A 74-page *Directory of Research Grade Scientists and Research Grants-Grade Scientists* in the National Park Service is now available from NPS Natural Resources Publication Coordinator Donna O'Leary, c/o Air Quality Division, P.O. Box 25287, Denver, CO 80225. The personnel are listed alphabetically by name and Region; information includes titles, addresses and phone numbers, major academic fields, degrees obtained and universities and years when they were won, plus topics of current and recent research.

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Five reports of research on the Gorda Ridge are available now and can be ordered pre-paid from the Oregon Dept. of Geology and Mineral Industries, 910 State Office Building, 1400 S.W. Fifth Ave., Portland, OR 97201-5528.

The Gorda Ridge is an area of hydrothermal vents and sea-floor spreading off the southern Oregon and northern California coasts – a subject of intense interest because of nodules of mineral deposits and unusual life forms that appear to get energy from chemical processes rather than sunlight. The report titles are: *Sea Cliff diving and sediment studies* by R. Karlin, \$5; *Soft-sediment hydrothermal vent communities of Escanaba Trough* by J.F. Grassle and C.L. Van Dover, \$5; *Biological results from DSV Sea Cliff explorations of the northern Gorda Ridge* by G.L. Taghon, \$4; *Studies of hydrothermal effluents on the Gorda Ridge* by R.W. Collier, \$5; and *Submersible observa-*

The disappearance of the majority of the endangered wood stork (*Mycteria americana*) population has been one of the most serious threats to the integrity of the avifauna of Everglades National Park. The storks have not died or ceased to reproduce, but have moved north, presumably to habitats where hydrologic conditions favor the wood storks' style of foraging. Ironically, a wading bird survey recently completed on Cumberland Island National Seashore, Georgia, indicates wood storks are now resident in the Cumberland Sound area and in 1986 and 1987, actually attempted to nest on Cumberland Island. The survey, originally funded by the Department of Defense to evaluate biological impacts of deep dredging for the nearby Kings

*tions and bottom-sample analyses of the Sea Cliff Hydrothermal Field* by J.S. McClain and P. Schiffman, \$5.

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Tandem tracking of research and resource management projects in the National Park System is described and advocated by NPS/CPSU Leader Chuck Douglas at the University of Nevada/Las Vegas, in an article to appear soon in the George Wright Society FORUM. Douglas recommends the use of project tracking software, several commercial versions of which are available, and details the workings of Protacs (Applied MicroSystems, Inc., P.O. Box 832, Roswell, GA 30077, (404) 475-0832) – used by his Unit.

A useful feature of the program, Douglas says, is the production of Gantt charts – chronologically oriented, horizontal bar graphs depicting segments of a project. Scheduled dates and actual dates of completion are shown and changes can be made on the chart via the Activity Update screen. "Graphic presentation of project events and deadlines allows more rapid visualization of a project's status," writes Douglas. "In the Tandem Tracking scheme, a research project would be followed immediately by resource management action."

The Tandem Tracking scheme, he concludes, "could dramatically reduce the time lag between research and management action."

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"Fifty feet above houndsman Gale Culver, an 85-pound female cougar snoozed away a gray afternoon in the spreading limbs of a fir tree. A dozen yards down the bluff, a smaller mountain lion lay concealed in another tree."

Thus begins Dick Cackle's *Oregonian* newspaper account (March 13, 1989) of the hounds pursuit that is part of a three-year study in northeastern Oregon by the state's Fish and Wildlife Department. The goal is to capture and release every mountain lion in the 500-square-mile Catherine Creek Game Management Unit of the Wallowa Mountains. Four hundred square miles is thought to be cougar habitat.

The study is believed to be the first serious attempt ever to capture and track every cougar in a specific habitat area. The best biologist guess till now has been that 1,800 to 2,000 cougars roam Oregon's mountains.

Bay Naval Submarine Base, was intended to determine which species of wading birds were using Cumberland's salt marshes at the onset of construction dredging activities.

In the late 1970s, Ron Odum, of the State of Georgia Department of Natural Resources, reported two wood stork colonies in coastal Georgia counties near Cumberland Island National Seashore. Prior to that time wood stork sightings on the coast of Georgia were sporadic, although storks may have been resident in nearby Okefenokee Swamp. In 1986, an Audubon aerial census located a large colony (250 pairs) at Dover Bluff, on the mainland to the north of Cumberland. Park staff verified wood storks nesting at Heron Pond on Cumberland Island in 1986, but did not determine the survivorship of young storks.

In 1987, the wading bird survey and a "wood stork watch" documented a second year of nesting at Heron Pond and found wood storks were roosting and foraging on Cumberland Island at all four seasons. As many as 55 storks were observed at the Heron Pond at one time. Since 1987 was a drought year, the pond went dry in May (alligators were seen leaving the area) and the wood storks abandoned the nesting effort. They did not attempt to nest at the pond in 1988.

Aside from observations of roosting and nesting, numerous sightings were made of wood storks foraging or resting in brackish ponds, in fresh water at Lake Whitney, or in tidal creeks. The total of 179 sightings for 1988 was much higher than expected. The wading bird survey found wood storks foraging in salt water, particularly at low to medium incoming tides. Salt water foraging is considered very rare in south Florida, perhaps due to the lower tidal amplitude. In south Georgia, small fish "run up" the estuaries as the tide comes in.

In summer 1988, aerial overflights found wood storks foraging regularly in both fresh and salt water habitats in the Cumberland Sound area. A series of two-hour flights flown over a standardized route in late September, 1988, counted 109 to 411 storks, with an average of 303 per flight. These data suggest that the number of endangered wood storks using the Cumberland Sound and the two islands to the north of it may exceed 500 birds (the total wood stork population in the U.S. is about 10,000 birds). Ground survey in 1988 located two additional roosting areas on Cumberland Island – one on the marsh shoreline near Plum Orchard mansion and one at Willow Pond, in the Sweetwater Lakes complex in the interior of the island.

This research and monitoring effort found far more wood stork activity on and near Cumberland Island than originally expected and suggests protection of wood stork foraging and roosting sites should become a key management concern for a park area outside of south Florida. The aerial surveys found more groups of storks near salt water habitats, but relative to their very limited area in the region, fresh water ponds and lakes were very heavily used by the storks. These sites are very prone to hydrologic changes and human induced disturbance. Priorities for Cumberland Island National Seashore are to protect tidal creeks used for foraging and to protect interior wetlands, such as Heron Pond or the South End Ponds, where small colonies of wood storks may roost, nest or forage.

Bratton is a research biologist and leader of the NPS/CPSU at the UGA Institute of Ecology.



# Pollution, Politics, Procrastination Are Triple Threat to U.S. Environment

One of the most impressive efforts ever mounted to document environmental concerns and match them with recommendations for remedial or preventive actions was carried out in 1988 by a steering committee and a task force whose members and chairpersons read like a scientific and environmental *Who's Who*. Their product, entitled *Blueprint for the Environment: A Plan for Federal Action*, edited by T. Allan Comp, is now available in book form.

The reader of this 335-page paperback (\$13.95 from Howe Brothers, P.O. Box 6394, Salt Lake City, Utah 84106) will find 511 approaches to national environmental problems, each one a reasoned solution for a specific concern best addressed by the federal government. Outlined in 90 "topic chapters" is "the massive effect of federal action on our environment and the remarkable range of those effects."

## Checklist For Action

According to Editor Comp, *Blueprint for the Environment* "becomes a checklist for responsible federal action, a guide to the complex workings of our government, and a clear indication of the astounding impact of federal environmental action – or inaction ... Yielding to the smaller concerns of polluters, politics, or simple procrastination will only allow the problems to multiply."

Of the 92 recommendations to the Department of the Interior, 26 directly address the National Park Service and/or activities in which its engagement is recommended. Comprehensive boundary studies, completion of wilderness studies, implementation of appropriate visitor carrying capacities for all NPS units (as now required by law), updating of the 1972 National Park System Plan, improvement of concessioner regulation, and improved protection of park resources from the effects of mining are among the specifics addressed.

## Section on Research

In a separate section on research, the NPS is urged to "help develop and support a specific legislative mandate for National Park Service research which recognizes the unique scientific value of the national parks, defines the role of research, and directs the Service to conduct natural, cultural and social science research as an essential element of its mission." In a related section entitled "education," the report calls on the NPS director to "seek legislation to provide a statutory mandate for park-based interpretation and education as fundamental to the mission of the national parks."

Personnel from the top echelons of 18 of the nation's most prestigious and influential environmental organizations were actively engaged in shaping the report and many of them were present at a 45-minute breakfast meeting in the White House to present it to President Bush.

# Prescribed Burn Interpretation Affects Visitors' Perceptions

*Editor's note: Dr. Joyce A. Quinn, social sciences associate professor at Cal/State/U, Fresno, submitted the following summary of her recently completed study for Sequoia and Kings Canyon NPs concerning visitor attitudes toward NPS fire program and policy.*

In response to a recommendation in a National Park Service report on fire management programs, a questionnaire was administered to 1000 people in Sequoia and Kings Canyon NPs during summer 1987 in order to identify visitor understanding of and reaction to the Park Service prescribed burning program.

The major objective of the research was to assess visitor awareness of and attitude toward prescribed burning and perceived threats to giant sequoia groves in Sequoia and Kings Canyon NPs. In accordance with directives of the report, the survey was designed to quantify visitor responses to forest fires management in the parks. Five major questions were addressed:

1. What is the visual reaction of visitors to seeing a burned area, smoke, or fire scars on giant sequoias in the park? Are these features readily perceived by the general visitor, and does the sight of them affect the visitor's park experience in a positive, negative, or neutral way?

2. Are visitors aware of the fire management program carried out by the Park Service? Is the visitor aware that the NPS has a program of prescribed ignitions and management of natural fires?

3. Do visitors understand that the fire management program is a tool designed to reduce wildfire hazards, encourage reproduction of the giant sequoias, and restore natural ecological processes?

4. What is the reaction to the NPS interpretive program? Is there sufficient information available to visi-

tors concerning the fire management program?

5. What is the preferred treatment of burned areas? Should the NPS try to hide fire scars or leave areas alone to regenerate naturally?

## Conclusions

1. Burned areas and smoke are generally visible to less than half the park visitors and neither has an impact on enjoyment of the visit. More visitors noticed fire scars on giant sequoias (87%) but stated that the sight enhanced the beauty of the trees. Visitors who had read *The Bark* or had been to the Visitor Center were more aware of the NPS burn program and were also more likely to notice the effects of fire.

2. Approximately three-quarters of all visitors were aware that the NPS regularly sets fires and allows them to burn. Foreigners and first-day visitors were less likely to be aware of the fire management program. Visitors who had taken part in an interpretive program (*The Bark* or ranger-guided walk) or had been in the park for more than one day were more likely to know about NPS fire policy.

3. Most visitors were quite perceptive concerning the role of fire in natural ecosystems. Those who were not included first-day visitors, foreigners, and those who had not read *The Bark*.

4. NPS interpretive information was very effective in informing visitors of fire management policies and the ecological role of fire. Over four-fifths of respondents who had seen such information said that it altered their opinion concerning the role of fire.

5. An overwhelming majority of visitors, with the exception of foreigners, were in favor of leaving burned areas alone to regenerate naturally rather than try to hide the effects of fire.

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## meetings of interest

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### 1989

**Aug. 1-3, NPS TRAINING WORKSHOP ON GLOBAL CHANGE AND BIOSPHERE RESERVES**, University of Tennessee, Knoxville, TN. Contact: Bill Gregg (202) 343-8122.

**Aug. 6-10, 40TH ANNUAL MEETING OF THE AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES**, at University of Toronto; theme, "Global Change." Contact: Nancy Dengler, Dept. of Botany, U/Toronto, Toronto, Canada M5S1A1; (416) 978-3536.

**Aug. 8-9, U.S. MAB SYMPOSIUM AND WORKSHOP ON COASTAL BARRIER BIOSPHERE RESERVES ON THE U.S. ATLANTIC SEABOARD**; part of the 40th Annual AIBS Conference in Toronto, Canada. Contact: Bill Gregg, (202) 343-8122.

**Sept. 11-17, MANAGING AMERICA'S ENDURING WILDERNESS RESOURCE**: A Conference in celebration of the 25th anniversary of the National Wilderness Preservation System; the Sept. 11-14 section will meet at the Radisson University Hotel on the Minneapolis campus of the University of Minnesota; the Sept. 14-17 section will meet in the Superior National Forest in northeastern Minnesota, and will include one- or two-day field trips. A *Proceedings* will be published. Contact: Charles R. Joyn, USDA Forest Service (RRWL), 310 W. Wisconsin Ave., Milwaukee, WI 53203; (414) 291-3610.

**Oct. 17-20, 16TH ANNUAL NATURAL AREAS CONFERENCE**, at the Hyatt-Regency in Knoxville, Tenn., with field trips to Great Smoky Mountains NP, Big South Fork NRA, and Cherokee NF. Contact: J. Ralph Jordan, Division of Land and Economic Resources, TVA, Norris, TN 37828.

### 1990

**March 20-24, FIRE AND THE ENVIRONMENT: ECOLOGICAL AND CULTURAL PERSPECTIVES**, an international symposium to be held in Knoxville, Tenn., multi-sponsored including NPS, U/Tenn, USFS, and the Society of American Foresters. Contact: Fire Ecology Symposium, Dept. of FW&F, U/Tenn, Knoxville, TN 37901-1071, (615) 974-7984.



# regional highlights

## Pacific Northwest

Resource Management Specialist Ed Menning professed disappointment in the National Conference on Mountain Management held in late February in Portland, Oreg., citing a low number of participants and "thin" representation from NPS. One moment of "excellence," however, was Yosemite Supt. Jack Morehead's "solid presentation on Future Trends in Mountain Management," Menning said.

A set of resolutions, not yet finalized, will be one product of the conference. They deal with such issues as user conflicts on public lands, lack of public understanding of wildland ethics, threats to water quality, and the need to balance user freedoms with resource impacts.

The University of Idaho CPSU now has available for distribution, copies of its resource database search program, written by Roger Hoffman. This program was developed to be used with the resource databases now being constructed in several Pacific Northwest parks. The completely menu-driven program comes with a demonstration database and is easy to install and use. The program allows for selectively filtered searches on any one or a combination of the 47 fields of information in the resource database. A variety of output options are also available including a matrix format useful in tracking inventory and monitoring efforts.

The program requires an IBM compatible machine with a hard disk. For a copy of the program, sample database, and user's manual contact Gerry Wright, Cooperative Park Studies Unit, College of Forestry, University of Idaho, Moscow, ID 83843, and enclose (2) formatted 5.25 inch disks or (1) formatted 3.5" disk.

Shirley Clark, PNR biologist, attended in April the second annual review of the Oregon State Implementation Plan for Visibility. Visibility in the Mount Hood Wilderness and the Central Cascade Wildernesses has improved since implementation of the State's Visibility Plan; however, visibility impairment at Crater Lake NP has increased. In 1987, 5 percent of daylight hours had significant impairment; in 1988, 18 percent were so affected. Of the 18 percent in 1988, 51 percent was attributed to a prescribed natural fire within the park boundaries. Unexpected weather conditions (see editorial this issue) had caused the fire to "blow up" and required park personnel to switch from a monitoring to a suppression mode. At the request of the Oregon Department of Environmental Quality, Clark and Mark Forbes (PNR Fire Coordinator) met on May 3 with DEQ members to discuss the natural fire program and visibility impairment at Crater Lake.

The Sierra Club, the Oregon Natural Resources Council, and the National Parks and Conservation Association have requested that the Interior Department's Board of Land Appeals reconsider its decision to allow exploratory drilling for geothermal resources near Crater Lake. Included with the request for reconsideration is a request that all exploratory drilling near Crater Lake be stayed pending resolution of the petition.

Peer review for the research on ecological effects of stocked fish on naturally barren high mountain lakes in North Cascades NP was held in May at the NPS/CPSU on the Oregon State University campus. Gary Larson, CPSU research aquatic ecologist, indicated that results would not be available before presstime. An article on the subject will appear in a future issue.

Biology of the Rhizosphere was the title of the 50th Annual Biology Colloquium at Oregon State University in Corvallis May 19, 1989. The whole area of interface between plant roots and the surrounding soil was the focus of the day-long meeting, which attracted about 200 scientists from the U.S. and the United Kingdom.

An international group of 10 scientists explored the various aspects of research in this field, providing background for current rhizosphere research and discussing biological interactions, current approaches, and applications of the discipline.

"What goes on below the ground is as important as the biological activities above the ground," according to John Lattin, OSU entomology professor and chairman of the colloquium. For information on the *Proceedings*, contact Dr. Lattin, Dept. of Entomology, OSU, Corvallis, OR 97331; (503) 754-2116.

## Midwest Region

A meeting was held in Minneapolis March 29-30 to discuss findings from a study of wolf decline at Isle Royale NP. The 26 participants represented NPS management and research, wolf ecology, disease and genetics specialties, and conservation biology.

The meeting was to summarize preliminary findings, seek consensus on immediate actions, and make recommendations on long-term study and management involving Isle Royale wolves. The format emphasized open discussions organized around short presentations by collaborators who have been involved in the Isle Royale wolf study during the past year.

The group consensus was the original three hypotheses set forth to explain the decline all remain as possibilities, and to this list a fourth possible cause should be added. The hypotheses are:

1. **Food shortage**, caused by moose age structure heavily skewed toward young moose.
2. **Disease**, with exposure to canine parvovirus (CPV) and Lyme disease confirmed and other possible parasite/disease influences remaining to be studied.
3. **Genetics**, as preliminary findings suggest that the entire population may be closely related and that loss of genetic variability may be substantial.
4. **Stochastic events**, with numbers now so low that random individual or population events may jeopardize the population.

Discussions centered around research scenarios developed to test the four hypotheses for wolf decline. The group recommended as priority management objectives scientific and educational efforts that will maximize new understanding of the dynamics of small populations. Findings need to be promptly published in scientific journals and interpreted for the public at large.

The Midwest Regional Office now has a cooperative agreement with the University of Nebraska to inventory, rank, map, and evaluate control measures for exotic species within 10 national park units. A 1985 exotic plant inventory for each park will be updated and

a complete exotic species list developed. Each park's exotic plant species will be classified as either innocuous or disruptive according to a set of criteria and the disruptive species will be ranked using a modified version of the Exotic Species Ranking System developed at Indiana Dunes. The distribution and population status of the most disruptive species will be determined and management recommendations will be provided. An evaluation of the Exotic Species Ranking System also will be included. A final report is due June 30, 1991.

The Midwest Region will sponsor a Research and Natural Resources Management Workshop July 10-14 at Scotts Bluff and Agate Fossil Beds. About 30 scientists and resource managers will discuss the status and use of Midwest Region CPSUs, park and Region research conferences, coordination of Midwest Region parks Geographic Information Systems, collections management, and inventorying and monitoring needs. A special topic will be management of fossil resources, with participants assisting Dr. Robert Hunt at a dig site at Agate Fossil Beds. Participants also will design the outline for an ecosystem inventory and monitoring program for Scotts Bluff.

## North Atlantic Region

While the national news was dominated by the Prince William Sound disaster, another spill of #6 Fuel Oil was quickly cleaned up at Cape Cod NS. Although many magnitudes smaller, this spill was still threatening in that it came ashore at the principal nesting area of piping plover and immediately north of an inlet opening into a highly productive back-barrier estuary, Nauset Bay.

The Coast Guard led containment operations, using NPS, contracted, and volunteer cleanup crews. Despite having to give the plovers a wide berth, and brisk weather through the night, cleanup was accomplished before the spill was carried through the inlet into the Bay.

The offender has not yet been found despite intensive searching. This incident provided a valuable test of the Seashore's oil containment plan and yielded important information on its strengths and weaknesses. Especially noted were the limitations of volunteer labor (however well-intentioned), the value of technical information in media relationships, and close communication between the various agencies involved.

The recent completion of a major inventory effort, which includes a numerical model of tidal driven circulation within Nauset Bay, had just been completed in preparation for possible oil spills in this heavily-used and navigationally-difficult area. For future refinements to the control plan, the model will be used to map the limiting velocity of containment boom effectiveness and thus allow for the design of choke points in the estuarine flow network. This will further minimize the penetration of surficial pollutants onto the habitats of the Nauset system.

Michael Soukup (Regional Chief Scientist) and Paul Buckley (CRU Leader at Rutgers) will be moving to the University of Rhode Island (Graduate School of Oceanography) this summer to establish the new Center for Coastal Research to serve coastal and marine parks in the North and Mid-Atlantic Regions. Much more on this later.



## Western Region

The Western Regional Office hosted an aircraft impacts workshop on March 30, during which a consultant summarized a final report on methodologies associated with the monitoring of ambient and aircraft sound levels and with the monitoring of aircraft flying over parks. Participants included representatives of the Western Regional Office, Washington Office, Pinnacles NM, Lassen Volcanic NP, and Sequoia and Kings Canyon NPs, U.S. Forest Service, and the U.S. Air Force.

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A Natural Resources Training Workshop was held at Santa Monica Mountains NRA on March 13-17. Over 90 managers, scientists, and technicians either participated in or benefited from plenary and concurrent sessions focusing on such topics as principles and management applications of geographic information systems, inventory and monitoring, alien plant and animal control, revegetation, and experimental design for resources management. The keynote address, entitled "Climate Change and Impacts on Flora, Fauna, and Landscape Processes in the Western United States," was given by Professor Daniel Botkin (University of California, Santa Barbara).

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Christine Schonewald-Cox (Research Scientist) and Thomas J. Stohlgren (Ecologist at the CPSU, UC Davis) recently published a paper entitled "Wilderness and the Protection of Genetic Diversity" in *Wilderness Benchmark 1988: Proceedings of the National Wilderness Colloquium*, USDA Forest Service General Technical Report SE-51.

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A recently prepared directory of Western Region Resource Management and Research personnel, initiated when there was some doubt that the WASO directory would be forthcoming, is now available from the NPS/CPSU at U/Cal Davis, located in the Institute of Ecology, Wickson Hall, Davis, CA 95616. "We have attempted to make this directory more inclusive and useful for people working with resource management in the Western Region," said Stephen D. Veirs, Jr., Unit leader.

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"Alternative Views of Reserve Design for Wildlife Managers" is the title of a paper by Charles Van Riper III and James F. Quinn in *1988 Transactions of the Western Section of the Wildlife Society* 24:12-17. The question of how best to design wildlife reserves for the long-term maintenance of native biotas is explored through three case studies:

(1) Small-scale field experiments that the authors have been conducting at U/Cal Davis on species diversity in experimental reserves of different sizes in a California annual grassland;

(2) The present controversy over the ability of the National Park Service to maintain the System's terrestrial large mammal fauna; and

(3) A scenario of reserve design for an endangered Hawaiian land bird.

The authors conclude that individual situations must be evaluated individually. The case for "only bigger reserves" in all cases is rejected as "not always the best strategy." Rather, the need is for "an adequate resource base inventory of organisms in designated reserves prior to acquisition, so that wise decisions are made regarding reserve design."

Van Riper is with the NPS/CPSU at U/Cal Davis; Quinn is in the Division of Environmental Studies there.

## Rocky Mountain Region

The Second Annual Science Summary of on-going and recently completed projects in Glacier NP reached *Park Science* from Chief Scientist Cliff Martinka just before presstime. The attractively illustrated 50-page booklet lists and describes the projects under 20 categories, ranging alphabetically from air quality and aquatic ecology to vegetational history (paleoclimate) and wildlife biology. Readers who want their own copy can write to Kathy Dimont at Glacier NP Science Center or call her at (406) 888-5441.

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Yellowstone NP hosted the Second Annual Northern Range and Fire Ecology meeting March 22 and 23 at Mammoth Hot Springs. Participants learned that Mark S. Boyce of the Department of Zoology and Physiology at the University of Wyoming would become director of the U/WY NPS Research Center.

Rick Klukas, Research Biologist at Wind Cave NP, was introduced as the incoming post fire research coordinator for Yellowstone. Rich reported for work on March 21.



**Dan Huff, Chief Scientist for the Rocky Mountain Region (right) welcomes Mark Boyce (he's the one with the tie) as director of the University of Wyoming/ NPS Research Center.**



**Half the participants in Yellowstone NP's Second Annual Northern Range and Fire Ecology meeting pause on their way to lunch. The other half couldn't wait.**

## Mid-Atlantic Region

Shenandoah NP hosted the Chief Scientists' Annual Meeting (April 24-28) this year, which was combined with the NPPP fund allocation. Resource Management staff presented an overview of their Long-term Ecological Monitoring program to the august group and demonstrated how the park GIS was used to aid in locating appropriate vegetation plots. This was followed by a field trip to view permanent vegetation plots and data collection procedures.

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A one-day Research Workshop was held in March at the Upper Delaware Scenic and Recreational River to present research findings from the nearly completed River Recreation Program. A report titled "Summary of Research Objectives, Accomplishments, and Future Needs for the Study of Appropriate River Recreation Use on the Delaware Water Gap National Recreation Area, New River Gorge National River, and Upper Delaware Scenic and Recreational River" has been prepared and is available from the Chief Scientist John Karish (address inside front cover). The report includes a listing of all publications produced by the research program along with the names and addresses of all researchers involved.

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Jeff Marion attended the first annual Northeastern Recreation Research Symposium to present a summary of the River Recreation Research Program and a paper on his work at the Upper Delaware Scenic and Recreational River.

## Southwest Region

In conjunction with a multi-year cultural resource inventory survey being conducted at Bandelier National Monument, two research projects are underway. The first is to develop an obsidian hydration calendrical curve in order to date the flake scars on obsidian artifacts. Small glass cells have been placed at 18 different elevations ranging from 5520' to 9000' at Bandelier. The cells will be left in place for one year to monitor the environment. Data from the cells will then be used to develop a calibration curve for dating obsidian artifacts from the area.

The second study is designed to identify which clay sources were used prehistorically in the ceramic industry at Bandelier. Eight of the 16 sources earmarked for study have been sampled and treated in a variety of ways in preparation for mineral composition analysis using x-ray fluorescence (XRF). If the clay can be extracted from prehistoric shards found in the area, their XRF signature can be obtained and compared to those from source areas. Those that match will suggest a link between the two.

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In April, SWR Chief Scientist Milford Fletcher chaired the western workshop on the biological effects of air pollutants. This gathering was sponsored by the Air Quality Division in Denver to obtain objective peer review of this NPS program. The focus was on adverse impacts (especially gases) on plants in the western U.S. A similar workshop is slated for the eastern United States and results of both workshops will be summarized by the Research Branch of the Air Quality Division.

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More work is being done by members of the Air Quality Division in Denver, the EPA's Region 6 office in  
**Continued on next page**



# Cape Lookout Turtle Monitoring

By Julie Parrish and Michael Rikard

The field rangers of Cape Lookout National Seashore (CALO) began monitoring marine turtles in 1976. Baseline data were collected from 1978 to 1983, during which time nightly patrols and tagging of the nesting loggerheads were conducted. Since 1984, CALO has continued to monitor turtle activity, document strandings, protect nest sites, relocate endangered nests (1987 being the exception) and protect hatchlings. CALO continues to be the most significant northern nesting beach for the Atlantic Loggerhead and supports the second highest number of nests in North Carolina. In addition to providing CALO with management data, the information gathered on CALO beaches

is an important link for state, federal and private Atlantic Coast sea turtle managers.

## Site Description

Cape Lookout National Seashore lies in the central coastal area of North Carolina between Beaufort and Ocracoke Inlets. The Gulf Stream passes within 20 to 40 miles of Cape Point, bringing in a variety of stranded turtles. Pamlico and Core sound creates the second largest eastern estuarine system and makes for excellent turtle habitat. The park is divided into three islands by Barden's Inlet and New Drum Inlet. The northernmost island is referred to as Core Banks North (CBN) and is approximately 22 miles long. Core Banks South (CBS) extends southward from New Drum Inlet

21 miles to the Cape Lookout Bight area. Both CBN and CBS have a northeast to southwest orientation and exhibit a low profile landscape. Shackleford Banks is 9 miles long and has an east-west orientation creating a higher dune system and larger areas of vegetation. All three islands are subject to constant and dramatic change by the actions of wind and waves.

## Methods

The Seashore is divided into three study areas, corresponding to the three islands comprising the Seashore. A Research Sector, which was a separate study area from 1978-1986, was located 1.25 miles north of the Lighthouse and extended southward to the Cape Lookout point.

CBN and CBS were patrolled daily from June through August by Student Conservation Association (SCA) Students and NPS rangers. Daily patrols of Shackleford Banks were discontinued since it yielded only two nests or 5 percent of the 1987 Seashore total. Any visitor reported turtle activity was investigated and foot patrols of Shackleford Banks (SH) were conducted very infrequently. Attempts were made to conduct early morning patrols of CBN and CBS, but logistical constraints sometimes extended patrols into the late afternoon hours. Some turtle activity may have been missed due to wind, tide, and rain, which obscure turtle tracks by afternoon.

Individual data sheets were completed for each turtle activity located. Nests in danger of erosion or overwash were relocated to safer areas. A "dig" occurred when the turtle excavated a body pit or disturbed a large amount of sand but the egg chamber was not located. Digs and nests were protected by markers; individual enclosures surrounded each. Enclosures were erected 50 days after the lay and maintained to provide funnel-shaped corridors from nest sites to the ocean. This provided rut-free access to the ocean for the hatchlings. Hatchling activity monitoring was conducted throughout October on a daily basis. All nests which could be relocated were excavated for follow-up data.

## Nesting

1988 nesting activity began on June 8 and continued until August 19, for a 72 day nesting season. The average nesting season from 1979-1988 is 80 days. Of the 100 activities documented, there were 40 nests, 10 digs, and 50 crawls. Crawls were turtle tracks not associated with any type of digging activity by the turtle. General results for each study area are given in Table 1.

Table 1. 1988 Activities by Study Area

Area	Nest	Dig	Crawl	Activity
CBN	13	5	23	41
CBS	27	4	27	58
SH	—	1	—	1
Totals	40	10	50	100

As can be seen from Figure 1, nesting activity has continued to decline since 1985. In 1988 CALO had 35 percent fewer turtle activities than in 1985, 33 percent fewer than in 1986, and 10 percent fewer than in 1987. Possibly this is a natural fluctuation, since nesting numbers decreased from 1980 until 1983 and then showed a slight upward trend from 1984 to 1985.

In past years, the research sector yielded a high percentage of the total park nests. In 1987 and 1988 the

## Southwest Takes Sweeping Look at Natural Resources

By Keith Yarbrough

At a successful workshop on Natural Resources Management, held in April 1989, 37 park participants from 26 Southwest Regional park areas and the CPSU at Texas A&M University, plus 8 from the Southwest Regional Office, discussed a broad spectrum of subjects, to wit:

Hardy Pearce of the Wildlife and Vegetation Division, NPS Washington Office, gave an overview of that division's organization and the services it can provide to field areas, the final Resources Management Program guideline, the revised Management Policies, NPS-77 developments, the NPCA Commission on Resources Management and Science Report, National Natural Landmarks, Global Climate Change and Biodiversity, the NPS's inventorying and long-term monitoring initiative, and the future of the Natural Resources Preservation Program.

Glen Kaye, Chief, SWR Division of Interpretation and Visitor Services, spoke on interpreting biodiversity.

Mark Scruggs, Chief, Research Branch, Air Quality Division, Denver, described that division's organization and services available to parks, updated Air Quality Division's activities, and gave the latest research findings on visibility and biological effects of air pollutants in the Southwest Region and Servicewide.

Dan Kimball, Chief, Policy, Planning, and Evaluation Branch, Water Resources Division, Fort Collins, described that division's organization and services available, and their recent activities in Southwest Region parks.

Tanna Chattin, SWRO Public Affairs Officer, talked on how to work with the media, avoid the pitfalls, and survive.

Ron Kerbo, Cave Specialist, Carlsbad Caverns, NM, described the new discoveries in Lechuguilla Cave, the concept of cave wilderness, and how to interact with a "non-supportive" public and live to tell about it.

Gerry Hoddenbach, Southwest Regional Biologist, covered Integrated Pest Management activities in the Southwest Region.

William Cook, NPS trainer at the Federal Law Enforcement Training Center, Glynnco, GA, handled liability risks for resources managers, using important case studies, Servicewide.

George Neusanger, Resources Management Specialist with Jean Lafitte National Historical Park and Preserve, spoke of the ongoing issue concerning hunting/trapping at Jean Lafitte.

Harry O'Bryant, Acting Unit Leader of the CPSU at Texas A&M University, discussed the services the CPSU can provide to Southwest Region parks.

Cliff Chetwin, SWRO Resources Management Specialist and Fire Officer, described FIREPRO III and fire management policy after the Yellowstone area fires. Jim Walters, SWRO Resources Management Specialist, tackled the Desert Parks Task Force and concepts of backcountry management (for which he was nearly lynched!).

Harvey Fleet, Geographic Information Systems Division, Denver, outlined the organization and services they can provide, and detailed case examples of GIS applications.

In addition, mini-workshops were held on preparation of contracts, computer applications for resources management, GIS applications, and integrated pest management applications in the Southwest Region parks.

## Regional Highlights

(Continued from page 19)

Dallas, Texas, and the SWR Division of Resources Management and Science staff in relation to the MAB effort with Mexican Biosphere Reserves. This work involves the heavy air pollution loadings that impact visibility and other air quality related values in Big Bend and Guadalupe Mountains NPs. There pollutants are transported by air masses emanating primarily from northeastern Mexico and the Texas Gulf Coast, although Guadalupe Mountains receives emissions as well from the El Paso, Texas/Juarez, Mexico urban area. A meeting in mid-June in Mexico City is discussing possible means to mitigate these impacts.

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A collaboration among staff of Big Bend NP, MAB Coordinator Bill Gregg, and staff members in the SWR's Division of Natural Resources Management and Science is undertaking to link Big Bend with two other Biosphere Reserves in the Chihuahuan Desert of northern Mexico. A series of meetings is fostering exchange of research findings and resource management information. Common problems are being analyzed, and a plan is being developed to restore the Bolson tortoise in these three areas.



research sector yielded only 23 percent and 28 percent respectively. The northern portions of CBS and CBN have continued to increase in total activity and actual nests. Figure 2 is a comparison of turtle nests by area from 1977 to 1988.

As shown in Table 2, CBN continues to be a significant nesting beach. Hatch success was 5 percent greater on CBN than on CBS, probably due to more relocations. 70 percent of CBN nests were relocated compared to only 15 percent of CBS nests. Incubation periods are longer on CBN than on CBS, possibly due to nest temperatures and sand grain size.

Table 2. 1988 Nesting Summary

	CBS	CBN	Totals
Nests	27 (68%)	13 (32%)	40
Digs	4 (40%)	5 (50%)	10
Crawls	27 (54%)	23 (46%)	50
Relocated	4 (15%)	9 (70%)	13
Excavated	23 (86%)	13 (100%)	36
Av. clutch	116 eggs	116 eggs	116
Av. hatch	73 eggs	97 eggs	85
Hatch success	61%	66%	63%
Av. incubation	64 days	67 days	65
Eroded/flooded	13 (49%)	4 (31%)	1

The 'dig' category proved very beneficial; digs were protected as nests. Further excavation and evidence of hatching enabled 9 of the 13 original activities marked as digs to be reclassified later as nests. These 9 were on CBS. Thirteen nests that were in danger of being overwashed or eroded away were relocated to safer areas; 70 percent of CBN nests and 15 percent of CBS nests were relocated. No appreciable differences in hatch rates for relocated and nonrelocated nests were noted.

### Hatching

Follow-up of nesting activity involved observing nest and dig sites for signs of hatching, recording relevant data, and excavating the site five days after the natural hatch. Often this can determine if a nest has been adversely affected by predation, human disturbance or environmental occurrences.

Follow-up studies were completed on 36 of the 40 nests. 2315 eggs hatched, giving an average clutch size of 113, yielding an average hatch of 85 turtles per nest. CBN had two nests with over 150 eggs each. It

took an average of 67 days for nests to incubate, which is longer than the CALO normal and probably due to cooler spring and summer temperatures. The overall hatch success for 1988 was 63 percent. Many of the relocated nests received overwash because they were not relocated to higher elevations, only a greater distance from the mean high tide. Seventeen, or 38 percent of the CALO nests were flooded or eroded away. The hatch success of nests which did not receive overwash was 77 percent; it was 43 percent for those that did.

It is agreed that nesting beach management programs can increase natural hatch success by 20 to 30 percent. Because of relocation efforts CALO's turtle program should regularly produce hatchlings from 70 to 85 percent of the clutch. The relocation program on CBN yielded 66 percent hatch rate. Hatch success on CBS was less because 49 percent of the nests were flooded or washed away. These were located 27, 39, and 41 feet from the mean high tide. Three CBS nests less than 41 feet from the high tide were totally washed away; 11 other nests, located from 42 to 90 feet from the mean high tide also experienced devastating overwash (hatch percentages of 0). Fourteen nests located from 12 to 115 feet from the mean high tide did not receive overwash, showing elevation of nest location to be as important as distance from high tide.

Any nest less than 100' from mean high tide on CBN was moved approximately 100' from high tide. Nests less than 15' from mean high tide on CBS were moved approximately 50' from high tide. Based on 1987 and 1988 data the 100' was fairly protective for CBN nests. The 15' distance used for CBS nests did not provide adequate protection.

High fall tides, 'northeasters,' and passage of hurricanes are fairly common at Cape Lookout. It is rare that a hatching season passes without extreme high tides, which overwash nest sites. During the 1988 hatching season, high tides on Sept. 26 and 27, a combination of lunar tides and a mild 'northeaster,' led directly to the death of 265 hatchlings on CBS.

During these high tides, nests #37 and 38 were excavated and 107 drowned hatchlings were found. The nest cavities were filled with approximately 8 inches of standing water. Motionless turtles were laid in rows of 10's, for approximately 45 minutes, the turtles were stimulated by slightly compressing their plastrons. Hatchlings were inverted (head

lower than tail) and the head raised and lowered to provide a route for drainage and a patent airway. By using these three techniques, 10 hatchlings were revived. These 'saves' were documented as live hatchlings. They were too weak to make the trek to the surf, but once they were placed on the intertidal zone they made it past the breakers on their own.

Predation and human disturbance at CALO are not as significant hatchling mortality factors as overwash. As long as vehicle tracks are eliminated from the nest site to the waters edge, and the hatchlings are not distracted by artificial light, ORV's are not as damaging as overwash. None of the CBS nests were predated by raccoons or ghost crabs. Five CBN nests showed signs of ghost crab invasion, but only one had signs of egg destruction. One nest had 0 percent hatch success and showed signs of a bacterial problem, attributed to a ghost crab's breaking eggs within 24 hours after the lay. It is felt that strict enforcement of the "No fish remains left on the beach" regulation has helped reduce the ghost crab population to a more natural level.

Four CBS nests and one CBN nest showed signs of human disturbance. Several people had watched the laying of nest #14; later an extravagant nest excavation was made and no eggs were left.

The Cape Lookout Lighthouse attracted hatchlings from a nest approximately one mile south of the Lighthouse. Some of them trekked 100' into the dunes before their tracks vanished. No light barriers were used in 1988.

Overall the 1988 turtle program was successful and yielded valuable information for managing this special species. It is hoped that future management will be based on the past 12 years of extensive data instead of being left up to individual's ideas or single year data.

### Recommendations

1. It is essential that either night or early morning turtle patrols be conducted on a daily basis from June 1 through October 31, since this covers most of the nesting/hatching period. Wind, tide, and rain erases turtle tracks and lessens data validity for that year when activities are missed.

2. Overwash and erosion have consistently been the most direct hatchling mortality factor. Therefore nests should be relocated to prevent overwash.

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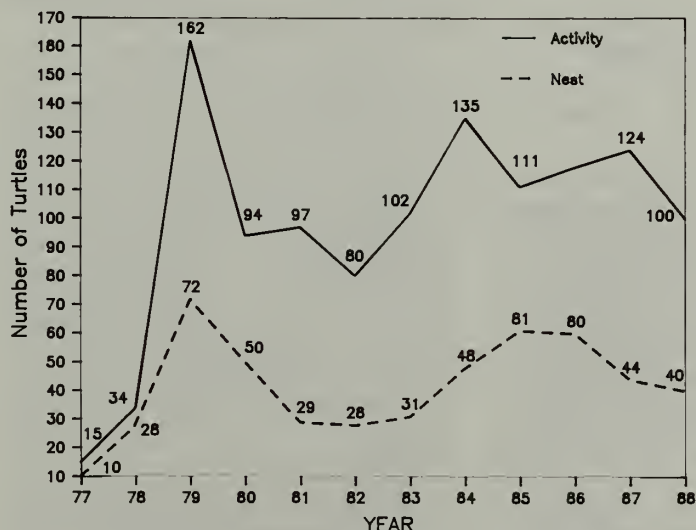


Figure 1. Cape Lookout Turtle Activity 1977-1988

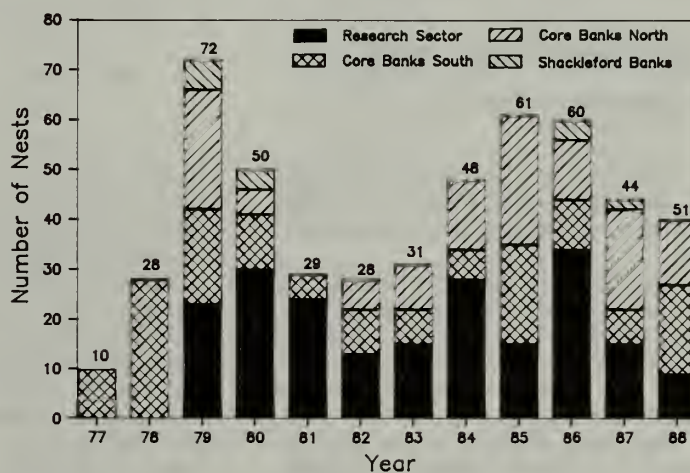


Figure 2. Turtle Nests/Study Area Comparison



# Evaluating the Effects of Ozone on the Plants of Great Smoky Mountains National Park

By James R. Renfro

Great Smoky Mountains National Park (GRSM) is one of the largest natural wildland reserves in the eastern United States. The 520,004-acre park contains approximately 1,300 native species of vascular plants including 130 native tree species. This large diversity of plant species can be attributed to the temperate climate, geologic history and the ranges of elevation, precipitation, topography and aspect. The scenic vistas that provide millions of visitors with seemingly endless views of forested mountains are among the important reasons people come to GRSM, the most visited national park in the National Park System (Peine and Renfro 1988).

**Background.** With such a large resource base, park management must be vigilant to see that these resources are not adversely affected from sources outside the park. Air pollutants, especially ground-level ozone ( $O_3$ ), are suspected of being major threats to man and his environment, particularly forested ecosystems. Park managers are mandated by the 1977 amendments to the Clean Air Act to protect the natural vegetation from air pollutants. Great Smoky Mountains NP has been designated a Class I area which sets as a goal, "the prevention of any future degradation of air quality caused by manmade air pollution." This is a very difficult mandate to fulfill and requires careful documentation of potentially adverse impacts.

Ozone is a pollutant of primary concern in the eastern U.S. It is the most widespread air pollutant in the nation and causes more plant damage than any other source (USDA 1987). It is referred to as a secondary pollutant (produced via primary components) and is formed in the air by the action of sunlight on nitrogen oxides (e.g. motor vehicle exhaust, the burning of coal and oil furnaces) and hydrocarbons (e.g. unburned gasoline vapors). Ozone is also a natural component of our air, existing in the upper atmosphere, where it protects us from ultraviolet radiation. It is the ground-level ozone that appears to be responsible for widespread injury of several plant species in the U.S., such as

tobacco, soybean, lettuce, grape, common milkweed, eastern white pine, black cherry, sassafras and many lichens (Stern et al. 1984, NPS-AQD 1988).

The National Ambient Air Quality Standard for ozone is 0.12 parts per million (ppm), which exceeds the level at which adverse effects to many plants occur. Preliminary studies of ozone injury and field observation by qualified plant pathologists suggest that damage may occur to many plants in GRSM.

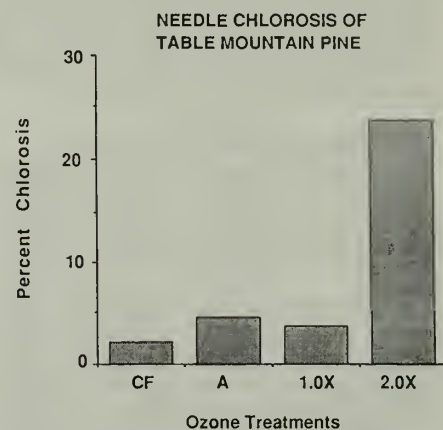
Early research addressing the effects of ozone on park resources was subjective and observational. While these approaches were appropriate for the initial assessment of ozone related impacts, the current projects must include specific peer reviewed Quality Assurance/Quality Control (QA/QC) elements. GRSM has just that kind of project underway.

**Objectives.** In 1986, the NPS Air Quality Division in Denver funded a four-year program at GRSM designed to establish any effects of ambient ozone on native plant species in natural communities, and further, to tie any observed effects to established levels of known ozone exposures. The major study objectives are to:

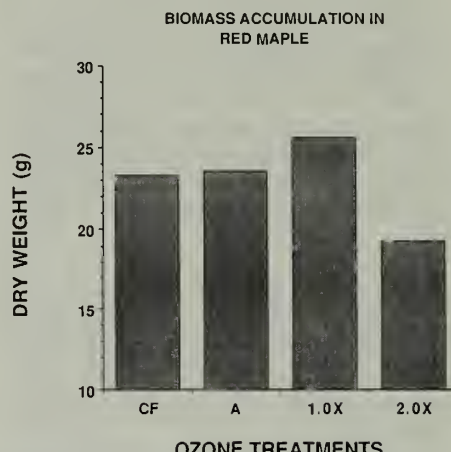
1. Determine the ozone sensitivity and assess potential impacts on native plant species collected in GRSM, as indicated by foliar injury and altered growth, and
2. Determine the effects of ambient ozone concentrations on native species in natural communities within the park.

## METHODS

**Study Site.** The open-top chamber facility became fully operational in June of 1987 at a site located at the GRSM Uplands Field Research Laboratory in Gatlinburg, Tenn. There are 12 plant-growth points (9 of which are growth chambers). Five of the open-top chambers have been equipped to dispense ozone from a generation system on site. Each chamber is a cylinder 10 feet in diameter and 8 feet high, covered with teflon-cured polyvinyl chloride panels. The cham-



*Needle chlorosis by treatment for Pinus pungens. Note increased yellowing in high treatment.*



*Biomass accumulation by treatment for Acer rubrum. Note decreased weight for high treatment.*

## Cape Lookout Monitoring

(Continued from page 21)

3. Fishermen should be required to discard fish scraps in the surf, reducing artificial increase of the ghost crab population, thereby lowering hatchling predation.

4. Each year it is documented that hatchlings from nests near the Cape Lookout lighthouse go into the dunes instead of toward the water. All nests within one mile North or South of the Lighthouse should be shielded from artificial light a few days prior to the expected hatch date.

5. When marking a nest or dig, measure 12" up from the surface sand at the nest site marker, use a permanent marker to circle the nest site marker at the 12" line. This will allow staff to monitor increase or decrease of

sand depth over nests. Any change in sand depth could cause the hatchlings to become trapped underneath. Sand deposition may also effect nests temperatures and length of incubation.

6. The nesting decline at CALO over the past three years may in part be due to problems associated with artificial light. Artificial lighting distracts and keeps potential nesting females away and disorients hatchlings on their trek to the sea. Therefore driving on or near the beach at night should be prohibited from June 1 until October 31.

*Parish is a Park Ranger and Rikard a Resource Management Specialist at Cape Lookout NS.*

ber system is similar to that developed by Heagle et al. (1973), and described in Hogsett and Tingey (1985).

**Treatments.** There are five separate ozone treatments with 2-3 chambers allocated per treatment. These treatments consist of:

1. Ambient air without chambers (N=3);
2. Ambient air in chambers (N=2);
3. Charcoal filtered air in chambers - the control (N=2);
4. 1.5 X ambient air in chambers (N=2);
5. 2.0 X ambient air in chambers (N=3).

Ozone concentrations are regulated by controlling output of the generator with a data-logger and manual flowmeters. Chamber concentrations are measured using ultraviolet photometric ozone analyzers and are sampled sequentially using solenoid valves controlled by the data-logger. Each chamber is sampled three times an hour and averaged to give an hourly average value. These values are maintained as the permanent record of ozone to which the plants have been exposed.

Because other environmental factors interact to affect plant growth and vigor, several meteorological parameters are monitored at the fumigation site. These include:



1. Air temperature – in and outside of the chambers
2. Relative humidity – in and outside of the chambers
3. Solar radiation – in and outside of the chambers
4. Wind speed and wind direction – outside of the chambers

**Plants Tested.** Plant species targeted for the ozone exposure facility are selected by the Air Quality Division staff, principal investigator, and GRSM technical staff. Species are considered for their biological importance to GRSM, suspected sensitivity, rarity, and ease of collection and growth. Also, a variety of growth forms (trees, herbs, shrubs, grasses and vines), are targeted for each testing season.

Nearly all of the species selected to date are suspected of sensitivity to ozone. Seed material for each species is collected the year before the plants are to be tested. Seasonal field technicians gather, clean, store, precondition and germinate the seeds in the fall and winter of each year. Seed collection activities include locating the species of interest, determining the optimum time for collection, monitoring the fruits and seeds on a weekly basis, and actual collection and propagation. Stratified seeds are sent to a commercial greenhouse to germinate and grow to suitable size before being placed in the exposure chambers in late April. After a two-week acclimatization period, exposures begin, running from just after the last frost in late April, to around the time of the first frost in early October. To date, 12 species have been tested; in 1989, 12 additional species are scheduled for evaluation.

**Plant Measurements.** While in the chambers, plants have their responses carefully examined and documented. All measurements made on plants adhere to the standard operating procedures (SOP) given in the National Atmospheric Precipitation Assessment Program (NAPAP), and Forest Response Program's *Quality Assurance Methods Manual* (Evans and Dougherty 1986).

A regimen of objective and subjective measurements are taken on the plants in the chambers. These parameters include:

1. Stem diameter
2. Stem height
3. Leaf length and width
4. Leaf number
5. Percent leaf injury
6. Leaf area
7. Vigor estimate
8. Gas exchange (including photosynthesis and transpiration)
9. Productivity (dry weights of roots, stems and foliage)

Response measurements fall into two categories: injury and growth. Injury responses are defined as any change in leaf, stem or flower condition that is pathological in nature and visible to the naked eye. Assessing and describing foliar injury under controlled conditions can be useful in two ways: (1) it determines how much functional foliage has been damaged by exposure to ozone and, (2) it develops guidelines for identifying observed field injury and damage (Evans and Dougherty 1986).

The visible symptoms we look for are deviations from a normal, healthy appearance, including loss or change of color and cell and tissue collapse. When injury occurs on the outer or epidermal layers of the foliage, and a pattern of interveinal spots develops on the top surface of the leaf, it is likely that ozone damage has occurred. This spotty pattern, known as "stippling" or "flecking" is the most classic visible indicator of ozone injury (USDA 1987).



The ozone fumigation site at GRSM showing exposure chambers filled with native plants (Photo by Jim Renfro)

Exposures to ozone can also affect various other growth processes, such as causing premature senescence or leaf drop, stem or foliage elongation, foliar morphological aberrations and injury to the flowers and fruit. All of these alterations can have a significant negative impact on the health of the plant and result in a reduction of biomass accumulation or alter its normal reproductive processes (Stern et al. 1984).

During the 1987 and 1988 summer field seasons, park staff identified 50 potentially ozone sensitive plant species in GRSM. These species were identified based on field observation of symptoms that appeared to be the result of ozone injury. The list includes 21 trees, 15 herbs, 9 shrubs, 3 vines, 1 fern and 1 grass. Most of these species have been collected and samples of leaves showing putative ozone injury have been pressed and are on display in the GRSM herbarium at Sugarlands Visitor Center.

Data analysis is currently being done at Appalachian State University in Boone, NC by principal investigator Dr. Howard Neufeld, a plant ecologist working with the NPS. An interim report on the project has been completed.

#### Suspected Sensitive Plant Species List for GRSM

Genus species	Common name
<b>TREES</b>	
<i>Aesculus octandra</i>	yellow buckeye
<i>Acer rubrum</i>	red maple
<i>Acer saccharum</i>	sugar maple
<i>Betula lutea</i>	yellow birch
<i>Cercis canadensis</i>	eastern redbud
<i>Cornus florida</i>	flowering dogwood
<i>Fraxinus americana</i>	white ash
<i>Halesia carolina</i>	silverbell
<i>Hamamelis virginiana</i>	witch-hazel
<i>Liquidambar styraciflua</i>	sweetgum
<i>Liriodendron tulipifera</i>	yellow-poplar
<i>Magnolia fraseri</i>	Fraser magnolia
<i>Nyssa sylvatica</i>	blackgum
<i>Picea rubens</i>	red spruce
<i>Pinus pungens</i>	table-mountain pine

<i>Pinus strobus</i>	eastern white pine
<i>Platanus occidentalis</i>	American sycamore
<i>Prunus serotina</i>	black cherry
<i>Rhus copallina</i>	winged sumac
<i>Robinia pseudoacacia</i>	black locust
<i>Sassafras albidum</i>	sassafras

#### HERBS

<i>Anemone quinquefolia</i>	wood anemone
<i>Anemone virginiana</i>	thimbleweed
<i>Aconitum uncinatum</i>	wild monkshood
<i>Apocynum cannabinum</i>	dogbane, Indian-hemp
<i>Asclepias exaltata</i>	tall milkweed
<i>Eupatorium rugosum</i>	white snakeroot
<i>Helianthus</i> spp.	sunflower species
<i>Menziesia pilosa</i>	minnie-bush
<i>Rudbeckia hirta</i>	black-eyed susan
<i>Rudbeckia laciniata</i>	cutleaf coneflower
<i>Sambucus pubens</i>	elderberry
<i>Solidago</i> spp.	goldenrod species
<i>Trautvetteria carolinensis</i>	tassel-rue, false bugbane
<i>Verbesina occidentalis</i>	crown-beard

#### SHRUBS

<i>Gaylussacia baccata</i>	black huckleberry
<i>Gaylussacia ursina</i>	bear huckleberry
<i>Lyonia ligustrina</i>	maleberry
<i>Rhododendron bakeri</i>	flame azalea hybrid
<i>Rhododendron calendulaceum</i>	flame azalea
<i>Rubus canadensis</i>	thornless blackberry
<i>Rubus idaeus</i>	red raspberry
<i>Stewartia ovata</i>	mountain stewartia
<i>Vaccinium</i> spp.	blueberry species

#### VINES

<i>Clematis virginiana</i>	virgin's-bower
<i>Rhus radicans</i>	poison ivy
<i>Vitis</i> spp.	grape species

#### GRASS

<i>Glyceria nubigena</i>	manna grass
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#### FERNS

<i>Pteridium aquilinum</i>	bracken fern
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## Ozone Effects (Continued from page 23)

**Ambient Ozone Monitoring, Permanent Plots and Field Surveys.** Once a species has been determined to be sensitive to ozone from this chamber study, by showing visible foliar or growth effects, a series of permanent vegetation plots and field surveys will be added to the study. In GRSM, ozone monitors are located on an elevational gradient consisting of Twin Creeks Area (2000 ft.), Look Rock Air Quality Monitoring Station (2700 ft.), and Cove Mountain (4100 ft.).

During the summer of 1989, Uplands Field Research Laboratory staff is operating a mobile ozone sampling vehicle throughout the park to determine variability in ozone concentrations at different levels of the forest canopy (e.g. above tree canopy, within the top of the crown 60-100 feet, under the crown 30-60 feet, and in the understory 1-30 feet), in different vegetation types, elevations, aspects, slopes and topographic locations. This information will provide tremendous insight into the variability of ambient ozone concentrations in the forested ecosystems of GRSM.

The ozone monitors at GRSM provide the opportunity to assess the effects of ozone at both the species and community level. Species level effects will be evaluated several times a season, and community level effects on an annual basis for the duration of the study. Community level work will continue beyond this study as part of the GRSM long-term ecological monitoring program.

### CONCLUSIONS

Very little is known about the effects of ground-level ozone on the natural communities of vegetation in GRSM. Understanding what biological processes are taking place in GRSM and being able to inventory and monitor these changes, will allow researchers to contribute to the knowledge about the effects of ozone on park resources and will better position the resources management team to make sound, land-management decisions.

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## In the Next Issue:

"Elwha Fishery Restoration Project Reviewed" by John Aho and John Meyer; "Tips About Some Chronometric Dating Techniques" by Judy Miles; "Status of Elk Research on Yellowstone's Northern Range" by Francis J. Singer; A Report on the 8th International Bear Conference in Victoria, B.C. from Kate Roney.

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