PARK SCIENCE

INTEGRATING RESEARCH AND RESOURCE MANAGEMENT

TERMITE TREATMENT TESTS AT
STATUE OF LIBERTY

PIKA PERSISTENCE
AT CRATERS OF THE MOON AND LAVA BEDS

ECONOMIC IMPACT ANALYSIS AT
FORT SUMTER

A ROLE FOR FOSSIL INVENTORIES
IN ECOLOGICAL RESTORATION

ATMOSPHERIC NITROGEN DEPOSITION AND
WESTERN PARKS

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UNITED STATES DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE

Cultural Resource Connections

I am delighted to present an article that focuses on cultural resource preservation as our cover story. Authors Mark Gilberg and Nan-Yao Su report on a relatively new termite treatment that is friendlier to the environment and more effective in the long term than many traditional termiticide applications. The study, a series of field trials in five units of the National Park System, is thorough and documents a viable alternative to deal with subterranean termites, a serious threat to our historic structures and objects. I am hopeful that the article will increase the awareness of this promising technique among cultural and natural resource managers and facility managers alike.

As always, in selecting an article for the cover I look for potentially broad applications of research, timely topics, less common subjects, or material that represents progress for the National Park Service. I also consider a subject's appeal, perhaps to a new or sporadic reader of *Park Science*. This article, which applies research to cultural resource preservation through manipulation of a natural resource, struck me as particularly intriguing.

Another link between cultural and natural resources is described in this issue's Highlights department. Resource and facility managers at Valley Forge National Historical Park have changed their traditional mowing operations that formerly managed 1,400 of the park's acres as lawn. Now, half of that acreage is allowed to grow into meadow, representing the historic landscape of the 18th century (see photo) and giving visitors a better visual approximation of the place George Washington used for the encampment of his troops.

Looking back to fall 1995, our cover article described a cultural-natural resource connection of another kind. The authors reported a technique used at Amistad National Recreation Area, Texas, to date rock art (pictographs) through chemical analysis of the paint. The process also identified natural crusts formed from bio-geo-chemical interactions among the rock substrate and paint that gradually cause the pictographs to appear faded. Through the application of natural sciences, the investigators improved the correspondence of the rock art to the cultures that produced them, enhancing resource interpretation and preservation.

There is opportunity for more of this kind of reporting in *Park Science* that explores relationships between cultural and natural resource management and the cultural and natural sciences. Even as many of us focus daily on preserving natural resources, our efforts contribute to the ecological integrity of a national park and the greatness of the National Park System, ideas that are culturally important. Or we may manage species (e.g., wildlife that symbolize the American wilderness or a particular time period), landforms (e.g., natural landmarks), or other phenomena (e.g., dark night skies) that are simultaneously natural and cultural resources. We may strive to understand the natural setting of a park that was important historically or prehistorically or the effect of natural processes (e.g., shoreline processes) on the preservation of cultural resources. Even cultural resource preservation can have implications for natural resources (e.g., armoring of forts and relocation of lighthouses).

Certainly, connections between cultural and natural resource management in the National Park System are abundant. Writing and reading about them encourages holistic thinking about the resources in our care and the scientific tools at our disposal. I invite you to share additional links among these resources in future issues of *Park Science*.

Jeff Selleck

Jeff Selleck
Editor

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DEPARTMENTS

COVER STORY

FEATURES

ON THE COVER

International symbol of freedom and justice, the Statue of Liberty is one of five national parks where researchers have tested new technologies to control termites. Results of the field trails are reported in our cover story on page 16.

news & views

Handling wolves on Isle Royale

"The attention given to [handling wolves on Isle Royale (volume 20(2):14–18)] is commendable and in the spirit of the federal agency whose principles are most similar to my own. It is hoped that the basic 'hands off/management of human visitation only' principle will be adopted by the other public land management agencies.

On the other hand, it is hoped that the National Park Service has or will adopt the principle of public involvement in policy—as have some other public land management agencies. It seems to me deplorable and out of spirit with NPS principles that no public seemed to be involved in this issue on Isle Royale. If this if true ... why is that?"

—Michael J. Riegert
Stetsonville, WI

I first wish to assure Mr. Riegert that the National Park Service (NPS) and Isle Royale National Park value the comments we receive from the public and that we make every effort to routinely invite the public to participate in our planning and decision-making efforts. For example, at Isle Royale we recently completed a general management plan, during which we hosted 10 public meetings and issued six detailed newsletters for the purpose of gathering public input into the planning process. As a result, hundreds of written comments from the public were received and considered. Presently, we are developing a wilderness and backcountry management plan that has provided ample opportunities for public input. A draft plan will soon be made available to the public for review and comment. Not only is public involvement required by the National Environmental Policy Act (NEPA) of 1969, it is simply good business to seek input from interested and knowledgeable citizens.

Wolf handling at Isle Royale began in the late 1980s, after extensive peer review by scientists and the U.S. Fish and Wildlife Service, the agency responsible for administering the Endangered Species Act. Under the NPS Management Policies in place at that time, nondestructive research and monitoring activities were considered a "categorical exclusion." Categorical exclusions are actions that, under normal circumstances, are not considered major federal actions and that have no measurable impacts on the human environment. By definition, categorical exclusions are excluded from further NEPA review and do not require public involvement in the decision-making process. Staff of the National Park Service felt the application of the categorical exclusion was appropriate for this particular monitoring activity because wolf handling techniques and protocols for handling were well established and had the concurrence of the U.S. Fish and Wildlife Service. In 1999, when the scientific review of the existing handling program was being conducted, the same categorical exclusion was applied. The park was not required to include the public in the evaluation, nor had any indication from any of the interested groups that they wanted to be included in the process. The review panel carefully considered all alternatives and felt that the decision made would best serve the wolf population at Isle Royale.

Lest this all sounds too bureaucratic, I also add that, at Isle Royale, there is no topic of more public interest than that of the wolf population and our wolf research program. In reality, the public, while not through a formal public process, is indeed involved in the program on a continual basis simply due to the program's high popularity, visitor curiosity on the topic, and the easy access to the researchers involved in the project.

And as an update, a recommendation made in 1999 to pursue other means of obtaining genetic material from the wolves is now in progress. A research project has been funded to examine wolf scat as a viable source of genetic material. That answer may be available by late 2003.

—Jack Oelfke
Isle Royale National Park

Honors awarded for natural resources work

The National Park Service recently presented six individuals with its 2000 Director's Awards for Natural Resource Stewardship and Science. The honors recognize outstanding achievements in the protection of ecosystem health in parks. This year, a sixth award was initiated, the Director's Award for Professional Excellence in Natural Resources, given in recognition of an NPS employee who fosters creative and innovative resource management practices in support of the mission of the National Park Service. The awards were given during the October 2001 meeting of the Natural Areas Association in Jacksonville, Florida. The people selected for these awards have, among other things, developed innovative vegetation management programs, advanced the use of sustainable practices, restored native ecosystems, and furthered our knowledge of coastal ecosystems.

Tamara S. Naumann, botanist at Dinosaur National Monument, Colorado-Utah, was the first recipient of the Director's Award for Professional Excellence in Natural Resources. Tamara designed and developed a vegetation management program that addresses weed management, restoration of native species and communities, and rare plant research and monitoring. Each of these components has applicability to other parks and agencies across the Colorado Plateau. Each component also has a strong educational aspect ranging from presentations to volunteers, to development of a rare-plant coloring book for youngsters. Tamara's involvement in national and interagency activities, volunteer activities, weed programs, weed management, and rare plant management serves as a model for parks on the Colorado Plateau and elsewhere.

Mike Finley, the immediate past superintendent of Yellowstone National Park, was the recipient of the Director's Award for Superintendent of the Year for Natural Resource Stewardship. Mike was recognized for his instrumental leadership in several complex and controversial areas of resource management, including the restoration of the gray wolf, management of bison, winter use in Yellowstone, and conservation of the Yellowstone cutthroat trout. Mike has shown strong support for scientific research and professional resource management. He has recognized the importance of good information in decision making, insisting that management decisions be science-based.

Chris V. Case, Facility Manager at Pictured Rocks National Lakeshore, Michigan, was presented the Director's Award for Excellence in Natural Resource Stewardship through Maintenance. Chris is a leader in the field of sustainable resource management and in the application of "green" technologies at the park. He has researched, developed, and introduced a comprehensive program encompassing sustainable energy (including solar), park-wide recycling, "biofluids" conversion, and product inventory and standardization. His efforts resulted in the conversion of six hand-operated campground water pumps to 24 solar chlorinated well pump systems; development of a solar power grid system for seasonal employee housing, and conversion of diesel additives and hydraulic fluid to soy-based biofluids in vehicles. He has worked closely with Sandia National Laboratory, U.S. Department of Energy, solar contractors, and the Michigan Soybean Promotion Council in applying these technologies in the park.

Several of the winners assembled in Jacksonville, Florida, in October to receive the awards from Mike Soukup, NPS Associate Director for Natural Resource Stewardship and Science. Pictured from left to right are: Chris Case, Mike Soukup, Samantha Weber, Tamara Naumann, and Charles Roman. Absent are Mike Finley and Tim Tunison.

The recipient of the Trish Patterson-Student Conservation Association Award for Resource Management in a Small Park was **Samantha E. Weber**, Chief of Natural Resource Science at Cabrillo National Monument, California. Through her hard work and determination, Samantha initiated the Division of Natural Resource Science at Cabrillo and implemented a geographic information system (GIS) program. Lacking professional and support staff for her program, she developed a network of resource managers and scientists in and outside the National Park Service to assist the monument. The natural resource science and GIS programs are now integral parts of the monument's operation. Samantha also has worked closely with scientists who wished to do research in the monument to ensure that their projects meet the monument's information needs.

J. T. "Tim" Tunison, Resource Management Specialist at Hawaii Volcanoes National Park, was presented the Director's Award for Natural Resource Management. Tim led and documented experiments to remove exotic plants in very small areas called special ecological areas (SEAs), and focused on methods that encourage native species to reestablish. He collaborated with scientists to use SEAs as living laboratories, formulating and testing hypotheses about native ecosystems and their vulnerability to exotic plant invasions, and devising practical techniques to restore and protect native systems. As a result, Tim and his resource management crew have effectively restored native ecosystems in the park ravaged by exotic plant infestations—a task some thought was hopeless. His successes have encouraged all the

NPS land managers of the Pacific islands to revisit their techniques for managing exotic species.

Dr. Charles Roman was the recipient of the Director's Award for Natural Resource Research. Dr. Roman is a research scientist in the Biological Resources Division of the U.S. Geological Survey. He has been studying the ecology of coastal ecosystems on behalf of the NPS Northeast Region's coastal parks for more than 15 years. Dr. Roman's research has been essential to the protection of coastal barrier national seashores in four major areas: evaluating effects of hydrologic alterations on freshwater wetland ecosystems; restoring salt marshes and small estuaries; quantifying changes in coastal ecosystem structure, function, and process; and evaluating relationships between sea level rise and salt marsh habitat structure. His innovative work has inspired much research interest in national parks among the scientific community.

Park Science congratulates all of the year's award winners.

Excellence in Geographic Information Systems recognized

The first National Park Service GIS awards for fiscal year 2001 were presented at the National Park Servicewide GIS Spatial Odyssey conference in Primm, Nevada, the week of December 3, 2001. Seven categories of awards were established. Of the seven nominees who won awards, five were from the Northeast Region. The winners were:

GIS Enabler: Mike Hill, Superintendent, Assateague Island National Seashore—for his all-around support of the GIS program at Petersburg National Battlefield (where he formerly served as superintendent). His efforts helped establish the program in this "small" park, resulting in big benefits to it and other national parks in the region.

Heroism: Richard Easterbrook, GIS Specialist, Petersburg National Battlefield—for his work in resource protection at New River Gorge, following two substantial floods in summer 2001. Richard provided GIS products such as maps of soils, hydrology, and archeology to aid an emergency response team in identifying damaged resources and infrastructure.

Community Service: Mark Adams (pictured above, left), GIS Specialist, Cape Cod National Seashore—for his success using GIS to involve disparate parts of the community in park decisions. **Richard Friedman**, GIS specialist with McKinley County, New Mexico—an NPS partner with Chaco Culture National Historical Park—also received this award. His outstanding knowledge of the prehistoric road system in the park, GIS skills, and cooperative attitude have helped predict the location of archeological sites so that they can be studied and protected cooperatively by the park, Navajo, Zuni, and other community partners.

Partnering: Mark Duffy, GIS Specialist, Assateague Island National Seashore—for establishing sustained and productive GIS partnerships with local and county programs. His efforts have helped focus GIS applications on coordinated regional planning to preserve park, county, and watershed resources.

Excellence in Application: Dan Hurlbert, GIS Specialist, Shenandoah National Park—for his extensive and high-quality work on GIS at the park, ranging from applications in fire to interpretation. Additionally, his technical GIS skills have been key in maintaining the park's scenic and rural character by modeling the potential visual impacts of proposed development.

Nontraditional Users: Dan Spotskey, Grand Canyon National Park—for supporting a murder trial through the preparation of maps showing the crime scene in the park. The GIS products were exhibited in court to help the judge and jury understand the complex terrain, its remoteness, and how the suspect—who pleaded guilty to the crime—pushed his wife over a cliff in 1993.

Team Project: Crater Lake National Park's maintenance and GIS programs and **the University of Hawaii**—for combining GIS and Global Positioning Systems technologies to effect real-time mapping of snowplows in relation to park roads and facilities. This project will have application in all snowy parks by allowing snowplow operators to maneuver their machines in whiteout conditions, minimizing damage to park signs, walls, and other infrastructure in addition to increasing personal safety.

Park Science congratulates the winners.

Articles wanted

The editor is always looking for articles to publish in *Park Science* that demonstrate the application of science to park management. If you can show this connection in on-the-ground resource management or by analyzing the implications of research findings for management, please consider writing an article. Additionally, the contributions of park operations such as interpretation, law enforcement, and facility management to preserving park resources are of interest, and the articles about them need not be written by researchers or resource managers. Features, brief highlights, announcements of meetings or conferences, book reviews, and summaries of journal articles are wanted. Complete guidelines for submitting all types of articles are available on the *Park Science* website at www.nature.nps.gov/parksci.

HIGHLIGHTS

Research reveals dinosaurs and other fossil wildlife at Big Bend

Research at Big Bend National Park, Texas, is increasing our knowledge of the environment when dinosaurs lived on the planet. Since 1995, vertebrate paleontologist Dr. Julia Sankey has been visiting Big Bend to find fossils of Late Cretaceous animals such as dinosaurs and mammals (fig. 1). The Cretaceous period ended 65.5 million years ago and was the last geologic period with dinosaurs. Big Bend is the most fossil-rich national park that preserves materials from the last 35 million years of the dinosaurs' existence. The park also contains some of the southernmost fossils from the Late Cretaceous period in North America. Sankey's work is contributing to painting one of the most complete pictures of a Late Cretaceous dinosaur ecosystem anywhere on the planet.

Sankey has focused on collecting fossils from microvertebrate sites. These are accumulations of small teeth and bone that often form in ancient stream channels. To recover the fossils, sediment is collected and washed through fine-mesh screens. With the aid of a microscope, fossil teeth and bone are then sorted out. The teeth can sometimes be identified to the species level and help provide a picture of the ancient ecology of the area.

Thirty-eight different kinds of fossil vertebrates have been discovered in the Talley Mountain area of the park, including dinosaurs, mammals, lizards, and other animals. Fossil teeth from nine plant- and meat-eating dinosaur species have been found (fig. 2). The plant-eating dinosaurs include dome-head (pachycephalosaurid), duck-billed (hadrosaurid), and horned (ceratopsian) dinosaurs. The meat-eating dinosaurs include an older relative of *Tyrannosaurus rex* and small theropods (*Saurornitholestes* sp. and *Richardoestesia* sp., including a new species, *Richardoestesia isosceles*). Many of the dinosaur teeth are small, probably from juveniles or younger individuals. Although no nest sites have yet been found at Big Bend, these teeth provide evidence that dinosaurs nested in the area.

Aside from finding new and different kinds of fossils, this research is helping scientists better understand the environments in Big Bend in the Late Cretaceous period. The environments in the park were different from areas further north. Big Bend was drier and may have had seasonal droughts and subsequent flash floods. Documenting the Late Cretaceous animals in areas like Big Bend, with such different environments, helps scientists better understand the ecology of the time. This may also help us understand why the dinosaurs went extinct at the end of the Cretaceous period.

Figure 1. Working first as a graduate student at Louisiana State University and now with the South Dakota School of Mines and Technology, Dr. Julia Sankey has been studying fossils of Late Cretaceous dinosaurs and mammals in Big Bend National Park since 1995.

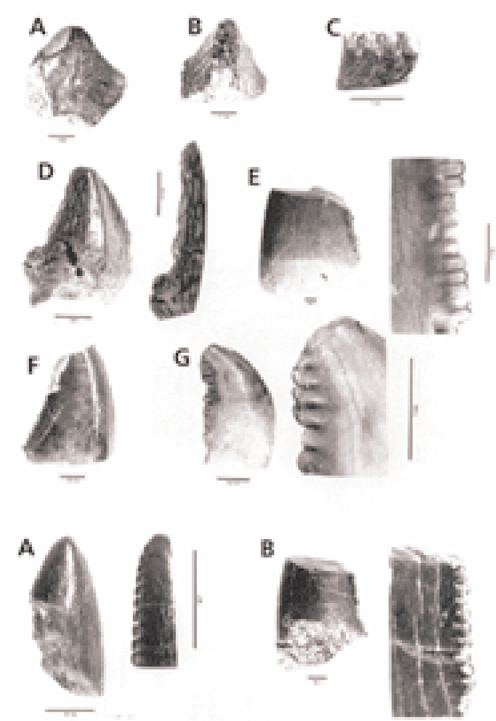


Figure 2. Teeth of plant-eating (A, B, and D) and meat-eating dinosaurs (remainder) from Big Bend. Letter A, bottom row, is a new species of small, carnivorous dinosaur that may have been a fish-eater (see Sankey, J. T. 2001. Late Campanian southern dinosaurs, Aguja Formation, Big Bend, Texas. Journal of Paleontology 75(1):208-15).

Black-footed ferrets:
An Endangered Species Act success story (so far)

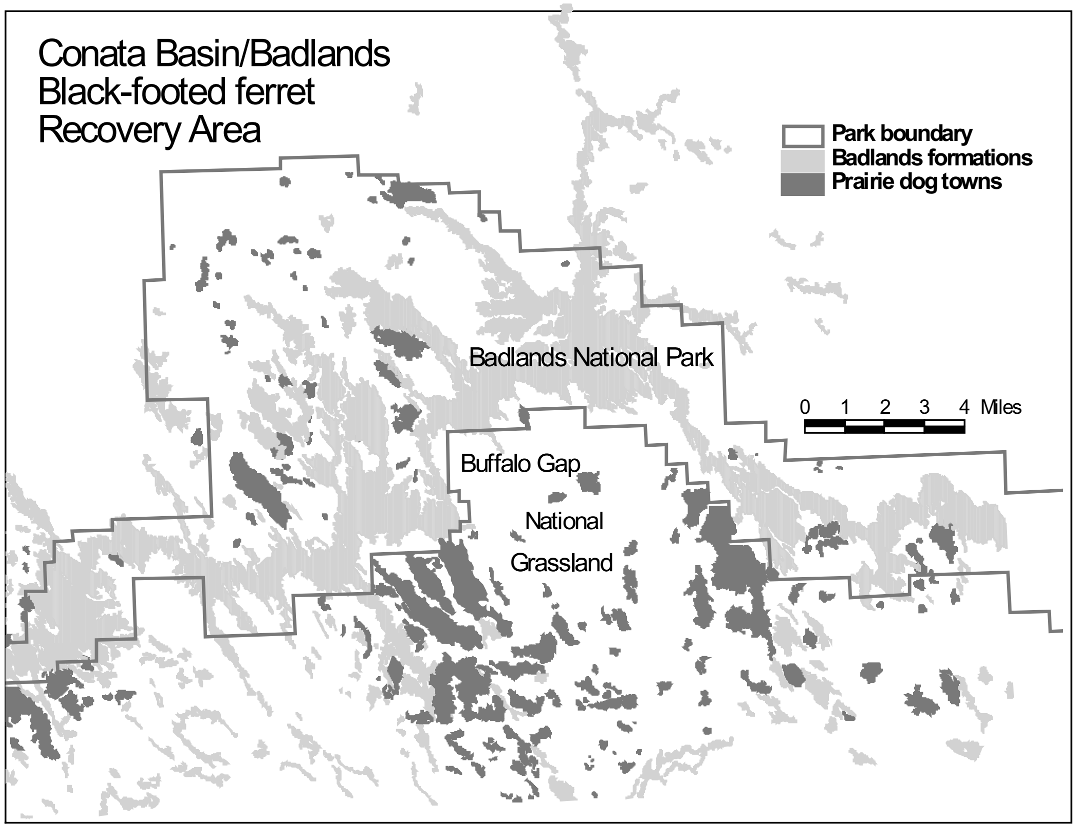
In 1994, parts of Badlands National Park and Buffalo Gap National Grassland (South Dakota) were designated as the Conata Basin/Badlands Recovery Area for the federally endangered black-footed ferret. A major, four-year reintroduction program began, which was described in detail in 1995 in *Park Science* 15(2):1,16–18. Designation as a "nonessential experimental population" allowed biologists flexibility and use of adaptive management techniques critical to bringing back from the edge of extinction this secretive, little-known species.

So where does the program stand nearly eight years down the road? Badlands Chief of Resource Management Brian Kenner and Black-footed Ferret Program Manager Doug Albertson report that the population has reached approximately 250 animals. Most of the ferrets reside on the national grassland because of the extensive black-tailed prairie dog complexes found in the vast prairie there. (Prairie dogs are the sole food source of the ferret.) As many as 55 wild-born litters (averaging approximately 3 kits/litter) have been born there in a single year. Perhaps most significant is that wild-born kits from this recovery area are now being captured and translocated to the Cheyenne River Sioux Reservation, to the east of the park, to help reestablish ferrets in a new area. These wild-born animals have a better survival rate than captive-born individuals, thus jump-starting a population that, because of the reservation's vast prairie dog towns, has the potential to number several hundred.

Disease, particularly sylvatic plague, canine distemper, and tularemia remain serious concerns to ferrets and prairie dogs. However, nonlethal blood sampling of predators in the area does not indicate an immediate threat. Plague, an introduced disease that has decimated prairie dog populations in recovery areas west of South Dakota, presently shows no indication of reaching the Conata Basin/Badlands. Establishment of a large, thriving ferret population farther east on the Cheyenne River Sioux Reservation will afford greater security from any future outbreaks and is therefore a high priority for the interagency ferret recovery team.

While Badlands National Park cannot by itself support a sustainable ferret population, it is a valuable part of the Conata Basin/Badlands population area, and now has a base-funded ferret management program for long-term monitoring of ferrets, prairie dogs, and related habitat parameters. In the future, should a disease outbreak or other factors decimate this ferret population, the park's experienced, professional staff will be able to translocate excess animals from other wild populations (that may themselves originate from the Conata Basin/Badlands population) to again restore the population. Only by having several large populations like the Conata Basin/Badlands will the species be secure for the long term.

Black-footed ferret as it was about to be released in 1994 in Badlands National Park.



Meadows recreate history at Valley Forge

At Valley Forge National Historical Park (Pennsylvania), 1,400 acres was once managed as lawn. When one mowing over the entire park was finished, the maintenance crews would start over again from the beginning, managing 10 passes a season. The lawns always had a "rough" look, but that was before the current Field Management Plan was implemented in 1994. Now, half of the acreage is mowed 15 times a season while the other half is left to grow up into meadow. Not only do the mowed areas look neater, but also the grassy meadows recreate the "sense of place" at historical Valley Forge, which is the reason the management plan was adopted.

In 1777, General Washington and his troops camped at Valley Forge in farmland where wheat, barley, and rye were cultivated. Some of the old 18th century farmhouses still stand. Today, because of the change in management that allows for high grasses waving in the breeze, the landscape resembles the farming community that existed just before the encampment.

The current management program does not reduce maintenance costs, and mowing is still done continuously. But now it is used to enhance historical interpretation. For example, where the boundaries of the 18th century farms are known, a meadow indicates the area of one farm while the adjacent lawn represents the neighboring farm. Thus, visitors get a sense of the size and relationship of the 18th century farms that was not apparent when mowing was more comprehensive.

Mowing also serves practical purposes. Mowed borders 50 feet wide frame the meadows and show visitors that these fields are here by design. Along the roads, the mowed borders allow motorists to see deer approaching. Between the fields and stands of trees, borders 20 feet wide serve as firebreaks. And, to invite visitors to walk in the meadows, there are mowed paths 15 feet across where people can exercise their dogs or jog without being surprised by snakes or being bitten by ticks.

The public heavily uses the park. Two million visitors a year come not only to see the historic sights but also for recreation in a densely urban region. Park managers were hesitant to reduce the lawn acreage when the plan to create the meadows was first implemented in 1994, so they introduced the change slowly, a hundred acres a year. Public reaction was at first undecided, but now it is very favorable; people like the more authentic setting and there are still 700 acres of lawn for picnics, volleyball, badminton, and other games.

To create the meadows, the regular mowing cycle simply stopped, and grasses already in place were left to mature; no additional seeding was done. What came up is about half native perennial grasses, mainly little bluestem *(Andropogon scoparius)* and purpletop *(Tridens flavens)*, and half exotics, including sweet vernal grass *(Anthoxanthum odoratum)*, orchard grass *(Dactylis glomerata)*, and creeping red fescue *(Festuca rubra)*. The latter is being closely monitored. It spreads via underground stolons with which it invades clumps of existing grasses. At present the native grasses seem to be competing well. If the creeping fescue or other invasive nonnatives should begin to take over, the park would need to periodically kill all vegetation in a field with herbicide and then seed the native grasses. Current management includes mowing the meadows once a year to prevent succession of woody plants that would lead to brushy cover and ultimately to forest. Mowing is accomplished before April 15 to prevent disturbing ground-nesting birds.

The "new" mowing program at Valley Forge allows some areas to grow up as meadows that are similar-looking to the farming community as it existed in 1777. Fifteen-foot-wide swaths maintain visitor access and enhance safety.

The change in management from lawn to meadow has undoubtedly affected the wildlife population at the park. Unfortunately, baseline population information was not collected before the meadows were established, so no data are available to show that populations of small mammals, snakes, frogs, songbirds, and raptors might have increased. However, that is the impression of frequent visitors to the park. Wildlife inventories are now under way.

An unquantifiable factor in the current Field Management Plan is the aesthetic one. The meadows covering the rolling hills of Valley Forge are beautiful. The largest field is 180 acres in an area in the middle of the park called the Grand Parade. In late summer when the purpletop blooms, the whole field has a purple cast, and close viewing reveals speckles of wildflowers among the grasses. Even in the winter, when the stalks are dead, little bluestem colors the landscape, not blue, but a warm, red ochre.

Information Crossfile

The threat of pathogens to biodiversity

The introduction of nonnative plant and animal species and habitat loss are commonly viewed as two of the primary causes of the decline and loss of species. However, the introduction of infectious disease-causing agents may be a threat of similar importance (Daszak, P., A. A. Cunningham, and A. D. Hyatt. 2000. Emerging infectious diseases of wildlife: Threats to biodiversity and human health. Science 287:443–49). The number of emerging infectious diseases of wild animals is increasing, as is the likelihood for transmission of diseases between humans, domestic animals, and wildlife. This poses a risk to the conservation of biological diversity in America's national parks and globally.

In addition to the well-known Lyme disease, rabies, and brucellosis, other infectious diseases can be transmitted among animal species and from animals to humans. In the United States these diseases include cryptosporidiosis, hantavirus pulmonary syndrome, and plague. Other diseases that can be transmitted between domestic and wild animals include canine distemper and canine parvovirus disease (that primarily affect members of the dog family), and strains of Newcastle disease (that affect poultry and waterfowl). An emerging fungal disease, chytridiomycosis even affects amphibians.

Human encroachment into wildlife habitat increases the likelihood for transmission of disease between humans, domestic animals, and wildlife species. Pathogens are also spread by people in several ways. The widespread introductions of animals into new areas poses a risk of transmitting infectious diseases to native animals that have never been exposed to the diseases. Infections may cause disease outbreaks, resulting in widespread mortality and possibly the extinction of local populations. This risk is particularly grave to endangered species.

Pathogens also may be introduced by international traffic in agricultural materials, domesticated animals, food crops, timber, and biologically contaminated wastes and ballast water. Evidence of this pathogen pollution (i.e., pathogens introduced by people) seems to be everywhere, even in Antarctic wildlife: antibodies to the infectious bursal disease virus, a domestic chicken pathogen, have been found in Antarctic penguins.

The authors noted the means to detect and control wild animal infectious diseases are inadequate. Although the conservation community has guidelines for preventing the spread of pathogens through the release of animals into areas where they have not lived, the guidelines have not always been followed. Between 1973 and 1986, conservation programs in the United States, Australia, Canada, and New Zealand translocated 700 terrestrial vertebrate animals, but 24% were not screened for diseases.

The authors called for extending the integrative, multidisciplinary approach taken to detect and control infectious diseases in humans to diseases in wild animals. Detecting and controlling diseases in wild animals must include investigations of the ecology, pathology, and population biology of host–parasite systems, and the identification of underlying causes of diseases and spread of diseases. Rapid dissemination of information by modern media and far-reaching legal support are also needed to control these diseases.

The effect of white-tailed deer on forest bird populations

Browsing by ungulates can cause measurable changes throughout a forest ecosystem, affecting the cycling of nutrients, energy flows across trophic levels, food webs, species composition, and the relative abundance of herbaceous and woody plants. In the United States, the conservation of game raised the densities of deer beyond previously known magnitudes. White-tailed deer *(Odocoileus virginianus)* are dominant herbivores in the eastern United States and may play a significant role in the structuring of forest ecosystems and the shaping of food webs. Such effects should be particularly noticeable in bird populations because bird species are sensitive to changes in vegetation volume and composition. W. J. McShea and J. H. Rappole monitored the density and diversity of vegetation and birds in eight 9.9-acre (4-ha) sites in northern Virginia to determine the effect of white-tailed deer on forest bird populations (2000. Managing the abundance and diversity of breeding bird populations through manipulation of deer populations. Conservation Biology 14 (4):1161–70). Four of the sites were fenced to exclude deer.

The density and diversity of plants in the understory of the fenced sites increased significantly. The abundance of birds, especially of species that feed on the ground and in the intermediate canopy, increased after the exclusion of deer. However, the species diversity of birds did not increase because the bird species changed with the succession of understory vegetation.

McShea and Rappole concluded that in protected areas deer may cause significant changes in the abundance and species composition of birds and that such changes can be reversed by removing deer to increase the diversity and density of understory vegetation.

State clean water programs and endangered species

Two key statutes that affect the National Park Service's efforts to protect fish and wildlife are the Clean Water Act and the Endangered Species Act. The goals of both laws refer to the protection and viability of organisms. The Clean Water Act called for eliminating the discharge of pollutants by 1985, attaining fishable and swimmable water by 1983, and prohibiting the discharge of toxic pollutants in any amount. The act contains statements about necessary improvements to conserve waters for the protection and propagation of aquatic life and wildlife. It established qualitative water standards that favor the propagation of fish and wildlife and set quantitative discharge limits that must meet these water quality standards. The Endangered Species Act called for the conservation of endangered and threatened species until they recover sufficiently to no longer need the protection of the statute. Various sections of the act define the roles and responsibilities of governments and private parties.

The protection and recovery of threatened and endangered aquatic species would benefit from a concerted application of both acts (E. Rosan. 2000. EPA's approach to endangered species protection in state Clean Water Act programs. Environmental Law 30(2):447–85). An impediment has been the role of states under the Clean Water Act. The act authorizes states to administer their own clean water programs and to issue their own permits for point source discharges into waters (National Pollutant Discharge Elimination System [NPDES]). Such programs must comply with minimum requirements of the Clean Water Act, but because discharges under state clean water programs are not federal actions, they do not trigger compliance with the federal Endangered Species Act. (However, in cases where the Environmental Protection Agency (EPA) retains approval authority over state programs or final permit actions [e.g., NPDES permits], the EPA is required to determine what effect a permit may have on threatened and endangered species.)

The EPA, the National Marine Fisheries Service, and the U.S. Fish and Wildlife Service spent almost a decade developing an interagency memorandum of agreement and national coordination procedures to protect endangered species from adverse effects of the state-administered clean water programs. Under the 1999 draft memorandum of agreement (that was subsequently implemented on 22 February 2001), the EPA agreed to consult with the Fish and Wildlife Service (and the National Marine Fisheries Service when appropriate) in the review of state discharge permits and water quality standards to protect listed species.

Although some issues still need to be resolved, the memorandum of agreement is expected to help improve communications between the agencies, help the conservation and recovery of threatened and endangered species, and generally improve water quality in the country.

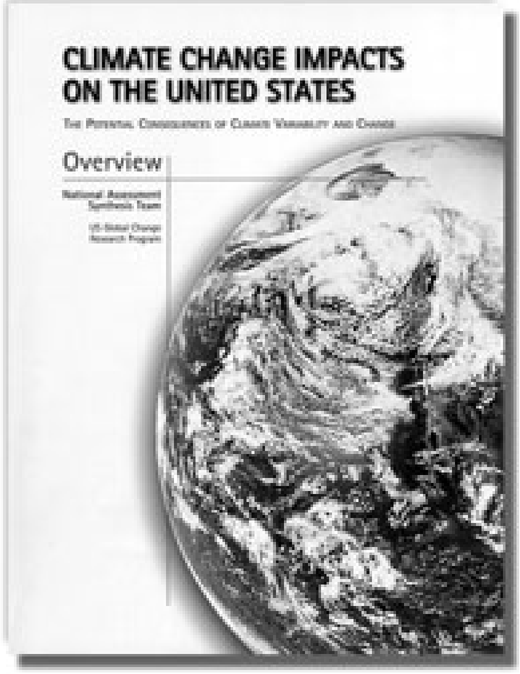
Problems in documenting population trends of the desert tortoise

Documenting trends of a species that is widespread but sparsely distributed can be difficult. Such is the case with the Mohave Desert populations of the desert tortoise *(Gopherus agassizii)*. Desert tortoises occur over a huge area and can be abundant in places. The listing of tortoises as threatened in 1990, because surveys suggested that some populations were declining rapidly, affected human activities in much of the desert Southwest. However, questions have arisen regarding the survey methods used before listing the tortoise.

Desert tortoises were studied at Joshua Tree National Park for six years to establish baseline population estimates and document changes over time (Freilich, J. E., K. P. Burnham, C. M. Collins, and C. A. Garry. 2000. Factors affecting population assessments of desert tortoises. Conservation Biology 14(5):1479–89). The researchers found that population estimates that do not account for weather changes are likely to be misleading. Their estimates, based on weekly spring surveys, varied substantially, particularly during wet and dry years. They found that apparent changes in population size were most strongly related to changes in the susceptibility of capturing the animals. In dry years the tortoises' home ranges decreased, captures decreased, and the effort required by the researchers to find each tortoise nearly doubled. The researchers concluded that tortoises are likely to be undercounted during dry years and that earlier studies conducted during droughts are probably not accurate, particularly if few tortoises were found.

The authors noted that the case of the desert tortoise may be true for other wide-ranging species. They urged that the U.S. Fish and Wildlife Service must ensure that listings of these species be based on tested methods and reliable data. Survey techniques must be carefully analyzed and reviewed to ensure that they are sufficiently robust to encompass both temporal and spatial heterogeneity inherent in ecosystems. Otherwise, the credibility of the Endangered Species Act can be challenged.

Climate change impacts on the United States



Long-term scientific observations show that the Earth's climate is now changing at a rapid rate, and indications are that even greater climate change is very likely this century. The National Assessment of the Potential Consequences of Climate Variability and Change, part of the United States Global Change Research Program, is a major ongoing effort to understand what climate change means for the United States. In 2000, the National Assessment Synthesis Team, a committee of government, university, industry, and nongovernmental organization experts, wrote an Overview of the Assessment (*Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*. Cambridge University Press. 154 pages). This overview is based on a longer, referenced "Foundation" report. The National Park Service participated in workshops on this report and reviewed various draft documents.

The overview summarizes past and predicted changes in America's climate, and discusses how the nation and its ecosystems may consequently change in the future. Regional overviews are also provided, focusing on possible climate changes in different parts of the country and key issues facing each region. The regional reviews cover the Northeast, Southeast, Midwest, Great Plains, West, Pacific Northwest, Alaska, islands in the Caribbean and the Pacific, and native peoples and homelands. In addition, the report addresses the key issues and implications of climate change for five sectors: agriculture, water, human health, coastal areas and marine resources, and forests.

Mike Soukup, Associate Director for Natural Resource Stewardship and Science, observed "This document contains much useful information relevant to the future of every park.... Although it does not focus on national parks or protected areas per se, potential impacts to them can easily be inferred." Among the key findings of the report of relevance to national park units:

- The United States will very likely become substantially warmer. Droughts and flash floods are also likely to become more frequent and intense. Heat waves are very likely to increase in frequency, but milder winters also are likely in some areas.
- Many ecosystems are highly vulnerable to the projected rate and magnitude of climate change. A few, such as alpine meadows in the Rocky Mountains and some barrier islands, are likely to disappear entirely in some areas. Others, such as forests of the Southeast, are likely to experience major species shifts or break up into a mosaic of grasslands, woodlands, and forests. Losses in local biodiversity are likely to accelerate.
- Sea-level rises are very likely to cause the loss of some barrier beaches, islands, marshes, and coastal forests through the 21st century.
- Increased carbon dioxide and ocean temperatures, combined with other stresses, will possibly exacerbate coral reef bleaching and die-off.
- It is very probable that rising temperatures will cause further permafrost thawing, damaging roads, buildings, and forests in Alaska.
- Reduced summer runoff, increased winter runoff, and increased demands are likely to compound current stresses on water supplies and flood management, especially in the western United States.
- Increases in water temperature and changes in seasonal patterns of runoff will very likely disturb fish habitat and affect recreational uses of lakes, streams, and wetlands.
- Coastal inundation from storm surge combined with rising sea level will very likely increase threats to water, sewer, transportation and communication systems, and buildings.

Those interested in reading the overview will find it posted on the Internet in html and pdf formats. The URL is: http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overview.htm.

Implications of climate change for coastal and marine resources

One product of the National Assessment of Potential Consequences of Climate Variability and Change, which was used in preparing the Overview of the Assessment, focused solely on the implications of climate change on U.S. coastal and marine resources (Boesch, D. F., J. C. Field, and D. Scavia, editors. 2000. *The Potential Consequences of Climate Variability and Change on Coastal Areas and Marine Resources:*

Report of the Coastal and Marine Resources Sector Team, U.S. National Assessment of the Potential Consequences of Climate Variability and Change, U.S. Global Change Research Program. NOAA Coastal Ocean Program Decision Analysis Series No.21. Silver Spring, MD. 163 pages). Prepared by a team of scientists, and subjected to peer review and public comment, this report compiles scientific studies by the government, private sector, and academia. The report examines changes in climate forces, including ocean temperatures, currents, hurricanes and storms, precipitation and freshwater runoff, and sea levels. Potential impacts of current climate variability and future climate change on shorelines and coastal developed areas, wetlands, estuaries, coral reefs, and ocean fisheries and other marine species are identified. Case studies are provided on several topics, including impacts on the South Florida regional ecosystems and mid-Atlantic estuaries. The report also outlines strategies for adapting to and coping with the consequences of climate change, and identifies areas of needed research.

This report has many implications for coastal parks. Among its findings:

- The rise of sea level is projected to accelerate during the 21st century, with dramatic consequences in low-lying regions. Coastal erosion, already a widespread problem, will be exacerbated by the sea-level rise. The Atlantic and Gulf coastlines are especially vulnerable to a rise in sea level, as well as an increase in the frequency of storm surges or hurricanes.
- As a result of changes in ocean conditions, the distribution and abundance of major fish stocks will probably change substantially.
- Unprecedented declines have occurred in the condition of coral reefs. Increasing atmospheric carbon dioxide is likely to further threaten coral, resulting in weaker skeletons, reduced growth rates, and increased vulnerability to erosion.

The report is available on the Web in PDF format at http://www.cop.noaa.gov/pubs/das/das21.html.

Paleontological inventories of caves

The Geologic Resources Division (GRD) recently published a technical report entitled *An inventory of paleontological resources associated with National Park Service caves* (Technical Report NPS/NRGRD/GRDTR-01/02). Authors Vincent L. Santucci (Fossil Butte National Monument), Jason Kenworthy (also at Fossil Butte), and Ron Kerbo (GRD) summarize the results of paleontological cave resource inventories conducted in 35 units of the National Park System since 1998. The inventories document both fossils preserved in the cave-forming bedrock and in the caves themselves. The authors discuss the significance of fossils associated with caves and the protection and management of these resources. The 50-page report includes color and black-and-white photographs. Copies are available by contacting the Geologic Resources Division, P.O. Box 25287, Denver, CO 80225-0287, and referring to publication NPS D-2231 (September 2001).

Sixth fossil conference proceedings available

Also available from the Geologic Resources Division is the recent *Proceedings of the Sixth Fossil Resource Conference* (Technical Report NPS/NRGRD/GRDTR-01/01). Editors Vincent L. Santucci (Fossil Butte National Monument) and Lindsay McClelland (GRD) have compiled 20 articles from the conference that deal with paleontological resource management or science and paleontological research on public lands. The fossil conferences began in 1986 and have grown into a rich partnership among federal, state, and local land management agencies and the professional and avocational paleontological communities. This report presents the papers given at the sixth conference: "2001: A fossil odyssey." The 214-page report includes color and black-and-white photographs. Copies are available from the Geologic Resources Division, P.O. Box 25287, Denver, CO 80225-0287; refer to publication NPS D-2231 (September 2001).

Book on lichens, mosses, and liverworts illuminates lesser-known forest life

Editor's Note: Botany professor Bruce McCune (mccuneb@bcc.orst.edu) of Oregon State University kindly reviewed the book *101 Common Mosses, Liverworts, and Lichens of the Olympic Peninsula* (ISBN 016-066471-3, copyright 2001) by Martin Hutten, Karen Hutten, and Andrea Woodward. This guide is part of a habitat-based survey of non-vascular cryptogams in the Olympic Peninsula and is published cooperatively by the U.S. Geological Survey, Canon U.S.A., Inc., the National Park Foundation, Olympic National Park, and the Northwest Interpretive Association. Copies are available from the Seattle (206-553-4270) or Portland (503-221-6217) U.S. Government Printing Office bookstores. McCune's report follows.

Continued in right column on page 37

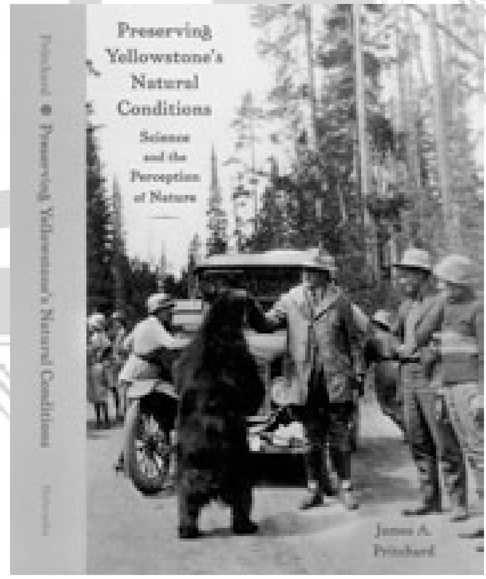
BOOK REVIEW

Preserving Yellowstone's Natural Conditions

SCIENCE AND THE PERCEPTION OF NATURE

By James A. Pritchard

A book review by Ryan Monello



Park managers, biologists, and other students of conservation generally recognize that some of the most visible management policies in the National Park Service are a direct result of issues that arose in Yellowstone National Park during the 20th century. In *Preserving Yellowstone's Natural Conditions*, James Pritchard provides the reader with a well researched chronology of these events in a novel and unbiased manner. As a resource specialist considering the effects of natural regulation in my own park, I highly recommend the book to anyone interested in or dealing with National Park Service management issues.

On the surface, the core of the book is focused on wildlife management policies in Yellowstone and the scientific, political, and social pressures that brought them about. These issues include ungulate management and the development of the natural regulation paradigm, the struggle to create a more natural bear population that eliminated assured viewing opportunities, terminating pelican control being practiced under the guise of fisheries management, and the creation of a free-ranging bison herd without supplemental feeding and husbandry techniques. Yet the real theme and interesting side of this book lies in the repeated stories of the struggle for the nation's first national park to become more natural, in both the management techniques and overall conditions.

"The book is focused on wildlife management policies in Yellowstone and the scientific, political, and social pressures that brought them about."

Not surprisingly, Pritchard uses the origins of the park and the ensuing bison and elk management issues to set the stage for the book. At first glance, I imagine any park manager might hesitate to pick up such a book, for these are clearly two of the most well-known topics in the National Park Service. But Pritchard goes well beyond simply describing a history that took place over 100 years ago. He clearly presents the mind-set of the managers: how the fear of bison and elk extirpation shaped management decisions of the late 19th and early 20th centuries and were crucial in bringing about the current abolition of hunting in almost all national parks, early predator control policy, and artificial feeding practices. This leads to an excellent overview of not only the biology associated with elk and bison management in Yellowstone, but also a general understanding of how politics and external forces can affect Park Service management.

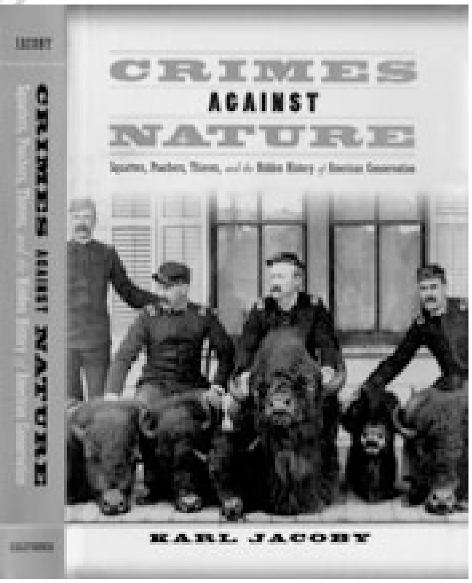
Pritchard, an adjunct professor of landscape architecture at Iowa State University, also has a keen ability to relate important park episodes in an accurate manner that is not driven by a particular viewpoint. One of the most often quoted but misunderstood sources in the scientific literature is the Leopold Report (i.e., *Wildlife Management in the National Parks*), which Pritchard sums up in one of the most accurate statements I have read: "Today the Leopold Report is remembered not for its recommendation that direct reduction [of the elk herd] was necessary and proper, but rather for its expression of what the panel members thought about the goals of the parks" (p. 211).

The important role that science can and has played in Yellowstone with respect to various park policies is also clearly shown in this book. Pritchard lays out good motivation and a solid reasoning for managers to rely on well done science to develop park policy and appropriate management decisions—especially with controversial issues. When Newton Drury, the director of the Park Service in the 1940s, was revitalizing an argument to end bear feeding in Yellowstone, he relied on the support of numerous scientists. Conversely, when science is distorted the resource can be threatened. This was the case in Yellowstone when studies indicated the necessity of destroying pelican eggs to protect fishery resources.

Because Yellowstone set the precedent for so many policies in the National Park System, there is a danger that after reading the convincing arguments set forth in this book one may assume that what was good for Yellowstone (e.g., natural regulation) is good for the parks in general. Pritchard does acknowledge the need for active management at times (p. 306), but overall gives a general impression that vigorous management action within a park is equivalent to an unnatural approach. This is not necessarily the case. (Although I certainly agree that unless the scientific evidence and reasoning is especially compelling, a "hands-off" approach is often more appropriate with regard to non-endangered, native species in parks.) Compare the elk scenarios of the Northern Range in Yellowstone with those of Rocky Mountain National Park. The former has an intact predator base, a large hunter harvest, and a largely intact winter range. The latter has no major elk predators, minimal hunter harvest, and a winter range that is largely developed. What works for one may not necessarily work for the other. Given that the book often engages in a Servicewide discussion, I think this point could have been made more clearly. However, I will be the first to admit that this is a relatively minor and finicky point given the excellent read and understanding of timeless issues that *Preserving Yellowstone's Natural Conditions* provides.

Ryan Monello is a Natural Resource Specialist at Rocky Mountain National Park, Colorado. He can be reached at 970-586-1360 and ryan_monello@nps.gov.

Preserving Yellowstone's Natural Conditions: Science and the Perception of Nature
By James A. Pritchard
Copyright 1999
University of Nebraska Press, Lincoln and London
ISBN 0-8032-3722-7, 370 pages



Crimes Against Nature

SQUATTERS, POACHERS, THIEVES, AND THE HIDDEN HISTORY OF AMERICAN CONSERVATION

By Karl Jacoby

A book review by William Supernaugh

This lavishly referenced work chronicles the social reaction of rural communities when traditional activities are criminalized by the establishment of environmental reserves. The author, an assistant professor of history at Brown University, takes the reader through 150 years of reaction to the creation of conservation laws that made illegal previously acceptable pastimes such as residency, hunting, fishing, and logging.

If you are like me, your bookshelves are lined with conservation-related books outlining the history of the conservation movement, the uplifting social setting that led to the creation of Yellowstone National Park, the setting aside of vast tracts of western land as national forest preserves, and later, establishment of a system of national parks and monuments preserving the places and events that demarcated American history and settlement patterns. Biographies abound of the politicians and patriarchs that are synonymous with the conservation movement—Marsh and Muir, the Roosevelts, and many more. Few books have looked at the seamier side of the conservation agenda—at the people who at the time had their livelihood, subsistence lifestyle, and freedom of movement curtailed by the sectioning off of the landscape for the public good—in effect excluding the local rural public. As noted by the author, "Landscapes do not magically reshape themselves in accordance with the desires expressed in legislation. Establishing a functioning conservation program would require not only new laws but new mechanisms for enforcement as well."

There are lessons to be learned from reading the discussion of the formation of the Adirondack reserves in New York, Yellowstone National Park, and Grand Canyon National Monument. Several books have recently examined past and recent activities that have affected native cultures. This work, too, examines the impact of conservation on the inhabitants and practices displaced by parks and preserves. Park rangers of today can relate to the reports of the Army's acting superintendent of Yellowstone in 1892, documenting the enforcement efforts of the soldiers when faced with the population settling around the fringes of the park, "... whose whole subsistence is derived from hunting and trapping."

> "Euro-Americans conveniently wrote these people out of the picture, following what the author characterizes as a history of pursuing environmental quality at the expense of social justice."

Jacoby cites several oft-repeated assumptions—"myths" in his words—that still crop up in any discussions of our nation's conservation history. There is one that I found worth examining—both as the prevailing thought of an earlier time and one repeated even as we establish parks a century later. Our earlier parks were not pristine wilderness areas free of human intervention but rather were and are, "part of a pre-existing native world." Protected areas were often home to significant human populations such as was found in Grand Canyon's Supai Canyon or included portions of a cycle of nomadic wanderings. Euro-Americans conveniently wrote these people out of the picture, following what the author characterizes as a history of pursuing environmental quality at the expense of social justice. This book will not be an easy read for some—but it raises questions and exhaustively documents a history lesson well worth studying. In the words of the author, "Memory ... is rarely an impartial record keeper. Details can fade over time. Understandings can shift as individuals re-imagine the past in light of current concerns."

William Supernaugh (william_supernaugh@nps.gov) is Superintendent of Badlands National Park, South Dakota.

Crimes against Nature: Squatters, Poachers, and the Hidden History of American Conservation
By Karl Jacoby
Copyright 2001, ISBN 0-520-22027-7, 324 pages
University of California Press, Berkeley, Los Angeles, London

New termite baiting technologies for the preservation of cultural resources:

RESULTS OF FIELD TRIALS IN THE NATIONAL PARK SYSTEM

By Mark Gilberg and Nan-Yao Su

Since 1995, the National Center for Preservation Technology and Training (NCPTT)—part of the NPS Directorate of Cultural Resource Stewardship and Partnerships—has sponsored a series of field trials to assess the efficacy and practical application of a new technology for the control of termites in historic structures and buildings. Many of these field trials have been conducted in our national parks where cultural resources are severely threatened by termite activity (fig. 1). These sites have proved ideal settings for this evaluation and for testing other new technologies. Moreover, the field trials have helped ensure the preservation of important cultural resources.

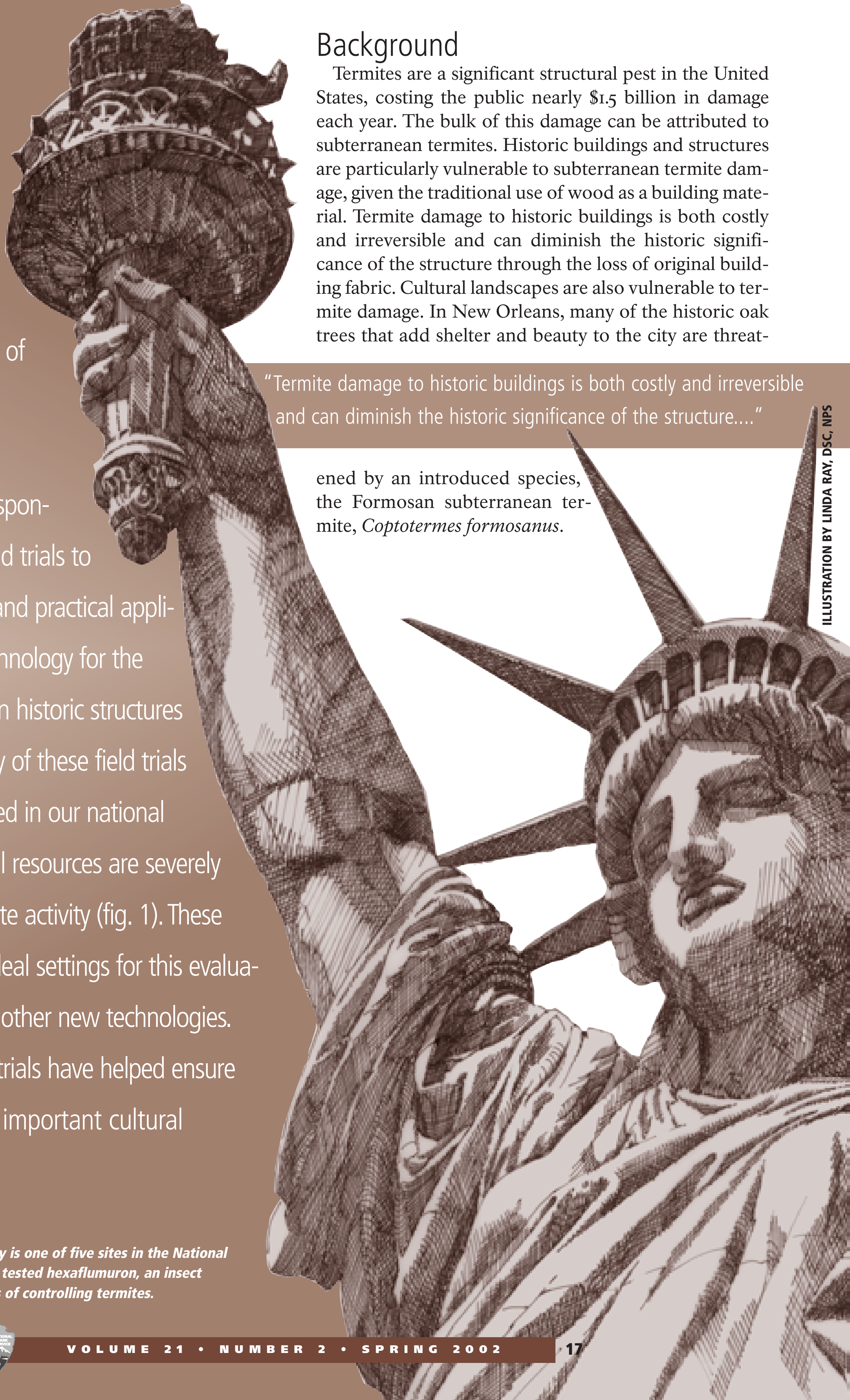


ILLUSTRATION BY LINDA RAY, DSC, NPS

Figure 1. The Statue of Liberty is one of five sites in the National Park System where scientists tested hexaflumuron, an insect growth regulator, as a means of controlling termites.

Background

Termites are a significant structural pest in the United States, costing the public nearly $1.5 billion in damage each year. The bulk of this damage can be attributed to subterranean termites. Historic buildings and structures are particularly vulnerable to subterranean termite damage, given the traditional use of wood as a building material. Termite damage to historic buildings is both costly and irreversible and can diminish the historic significance of the structure through the loss of original building fabric. Cultural landscapes are also vulnerable to termite damage. In New Orleans, many of the historic oak trees that add shelter and beauty to the city are threatened by an introduced species, the Formosan subterranean termite, *Coptotermes formosanus*.

"Termite damage to historic buildings is both costly and irreversible and can diminish the historic significance of the structure...."

This species can construct nests within the dead heartwood of the tree eventually weakening it to the point where it is unstable and falls in bad weather.

Conventional methods for the control of subterranean termite infestations rely heavily on the use of organic (i.e., carbon-based) insecticides to provide a barrier for the exclusion of soil-borne termites from a structure. Typically, large volumes of liquid insecticide are applied to the soil beneath and surrounding an infested building. Poisoning the soil is not a sustainable practice and may contaminate groundwater as well as pose health and safety hazards. Moreover, such an approach is not altogether effective. Creating an uninterrupted barrier of treated soil beneath an existing structure is extremely difficult, and gaps in the barrier invariably allow access to the structure. Also, because the soil treatment only deters termite attack, the vast majority of subterranean termites are unaffected. Conventional soil treatments often result in physical damage to the structure; they require the drilling of often disfiguring and unsightly holes in the foundation floor before liquid insecticides are injected into the soil.

"Poisoning the soil is not a sustainable practice and may contaminate groundwater [and] pose health and safety hazards."

New termite baiting technologies

In response to these concerns, a number of new baiting technologies have been developed in recent years as an alternative to conventional liquid insecticides. Of these, baits containing the insect growth regulator, hexaflumuron, have proved most promising in successfully eliminating subterranean termite populations at or near structures. Hexaflumuron inhibits the synthesis of chitin, which is essential for the formation of insect exoskeleton, but is virtually harmless to vertebrates ($LD_{50}>5{,}000$ mg/kg[1]). The treatment uses a monitoring and baiting procedure, whereby hexaflumuron is delivered by foraging termites to eliminate the entire colony population. The procedure is marketed currently as the Sentricon® Termite Colony Elimination System (Dow AgroSciences, Indianapolis, Indiana) to authorized pest control operators. Studies using the Sentricon system or its commercial prototypes have confirmed that termite colonies of several million individuals can be suppressed to the point of inactivity (or observed elimination) using less than 1g of hexaflumuron. Moreover, elimination of colony populations creates a zone of termite-free soil surrounding a building for several years.

"Termite colonies of several million individuals can be suppressed to the point of inactivity ... using less than 1g of hexaflumuron."

The Sentricon system employs a cyclical process of monitoring and baiting for termite activity. Initially, a technician installs Sentricon stations containing monitoring devices in the soil surrounding a structure. When termite activity is discovered in a station, the monitoring device is replaced with bait containing 0.5% hexaflumuron (fig. 2A). Foraging termites feed upon the baits and thoroughly distribute the hexaflumuron throughout the colony population. Unlike conventional termiticides, hexaflumuron is a slow-acting toxicant that kills termites only when they molt, every 1-2 months. Thus, dead termites do not accumulate around the bait that would otherwise repel other foraging termites and prevent further uptake of the bait. Several months may be required to achieve control but the end result is complete elimination. Once the colony is eliminated, a return to monitoring continues to detect further termite activity.

Hexaflumuron targets only subterranean termites; drywood termites and other insect species remain unaffected. Also, it only impacts those colonies at or near the site to be protected. Hexaflumuron can not be spread over a large geographical area and thus threaten the extinction of *C. formosanus* as a species. In fact, experimental results to date suggest that re-infestation always occurs but at a slower rate than in the absence of hexaflumuron due to an overall decrease in termite population levels around the site.

Field trials

NCPTT-sponsored field trials involving the use of Sentricon have been conducted at a number of National Park System sites particularly in the Southeast and the Caribbean where subterranean termite activity is most pronounced and threatens many historically significant structures. In the greater New Orleans area the annual cost of termite damage and treatment is estimated at $300 million. The historic French Quarter is particularly threatened because of the widespread use of wood as a building material and shared-wall construction practices that make pest control difficult (Freytag et al. 2000). Much of this damage can be attributed to the Formosan subterranean termite, which was introduced from Asia after World War II. This species is characterized by extremely large colonies and, unlike other subterranean termites, is capable of forming aboveground nests.

[1] Lethal Dose, 50%, refers to the amount of insecticide that, if administered to a population, will cause 50% of the population to die. It is usually expressed in terms of milligrams of insecticide per kilogram of subject body weight.

To date, the National Center for Preservation Technology and Training has sponsored field work involving the use of Sentricon at San Juan National Historic Site, Statue of Liberty National Monument, Cane River Creole National Historical Park, Virgin Islands National Park, and New Orleans Jazz National Historical Park. These trials represent a joint effort by NCPTT and its partners—the University of Florida, the New Orleans Mosquito and Termite Control Board, and Dow AgroSciences—to advance our knowledge of subterranean termite control in historic structures. In addition to establishing the efficacy of Sentricon, these trials yielded considerable information regarding the ecology and behavior of subterranean termites. They also provided opportunities to evaluate several new technologies for detecting termite activity, including thermal imaging and acoustic emissions. We highlight below the methods used to (1) identify termite infestation, (2) measure termite activity for bait efficacy assessment, and (3) apply baits, and the results from several of these trials.

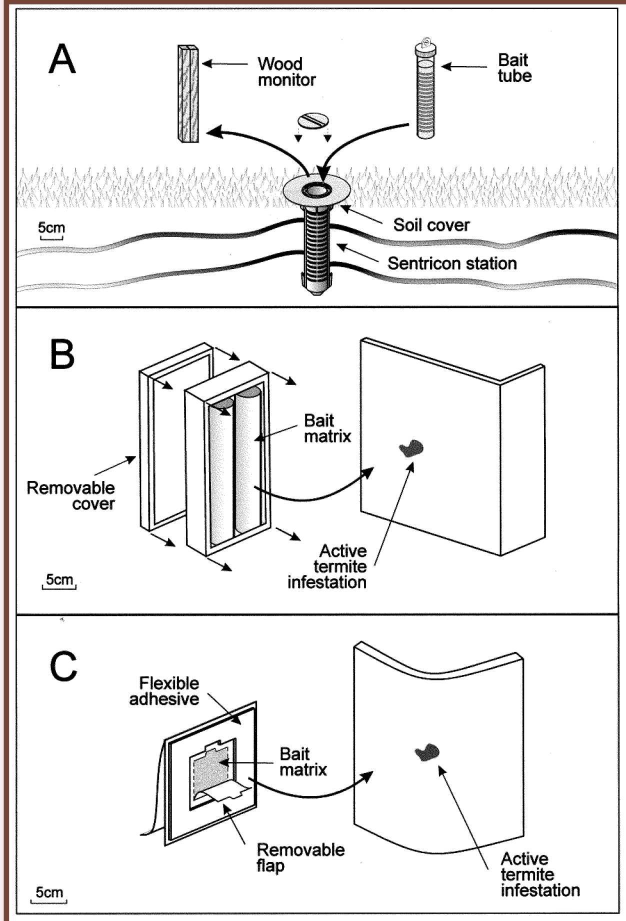


Figure 2. The field trials used three types of bait stations to deliver the hexaflumuron baits: (A) in-ground Sentricon station, (B) hard-style aboveground bait station, Recruit AG, and (C) soft-style aboveground bait station.

Identifying termite infestation

The first step is to identify the whereabouts of termite activity or damage. At the Statue of Liberty National Monument, signs of termite activity such as swarming, wood damage, and mud-tubes as noticed by park personnel led us to identify three sites of live termite activity in the structure (fig. 3): boiler room (BOL), display case (DIS), and sally port (SAL). Another important tool in identifying termite activity in soil is the survey using wooden stakes (Su and Scheffrahn 1986). Researchers drove spruce stakes in soil surrounding the exterior walls of the monument to detect termite activity. The survey revealed two activity sites, one in the soil outside the boiler room and the other at the sally port exit (EXT) (fig. 3). As shown in figure 3, researchers identified four clusters or populations of the eastern subterranean termite, *Reticulitermes flavipes*, at the Statue of Liberty (Su et al. 1998).

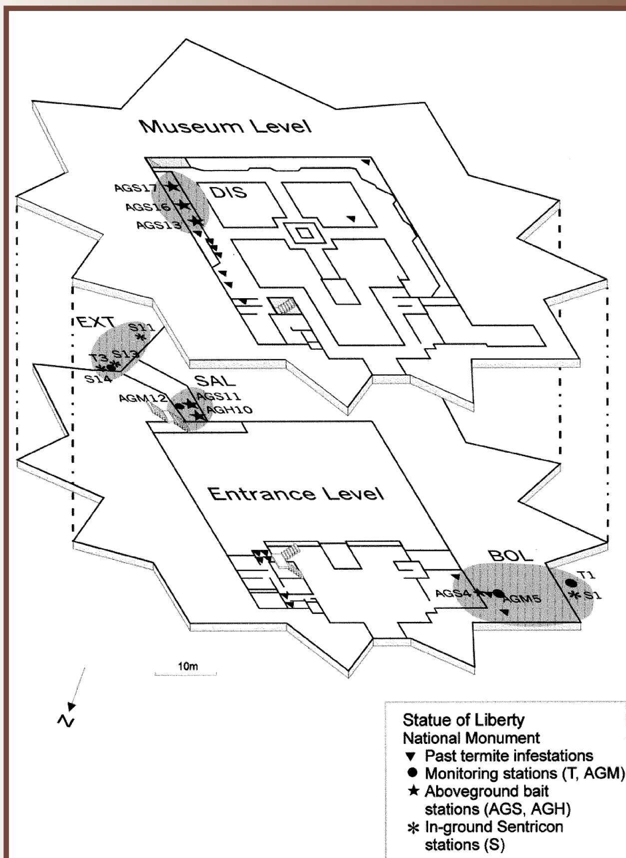


Figure 3. Site inspection and stake survey revealed four clusters of* R. flavipes *activity in the Statue of Liberty National Monument. Termite activity was measured using underground (T) and aboveground (AGM) monitoring stations. Three types of bait stations delivered hexaflumuron: in-ground Sentricon station (S), aboveground bait station Recruit AG (AGH), and soft-style aboveground bait station (AGS).

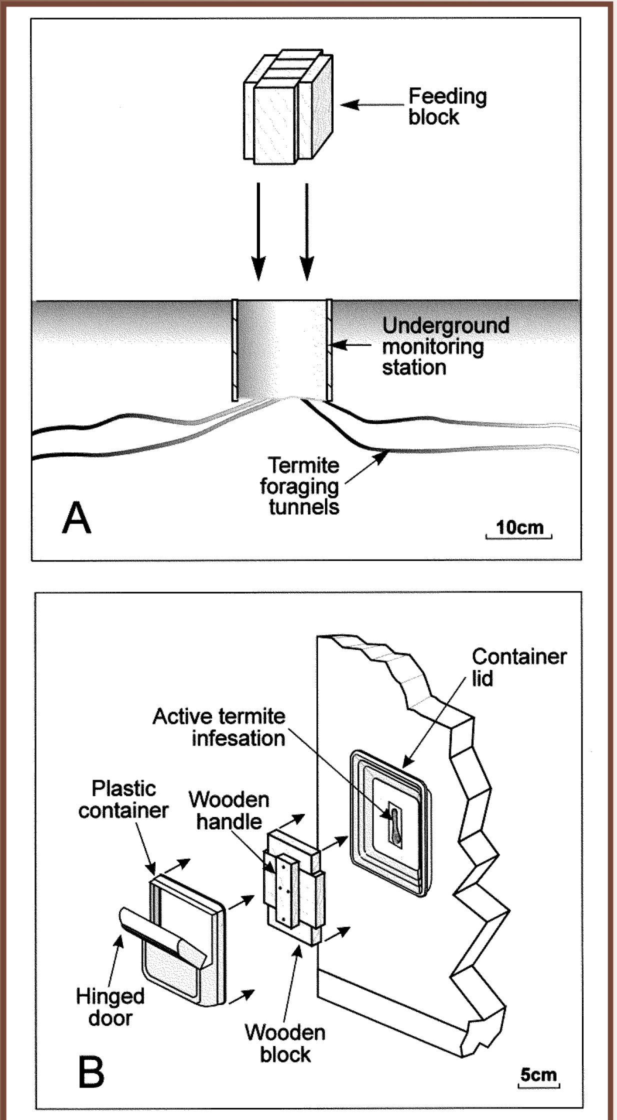


Figure 4. The field trials used underground (A) and aboveground (B) monitoring stations to measure termite activity at several historic sites.

Measuring termite activity

Termite activity must be quantified before, during, and after bait application in order to properly assess the effects of the baits on the populations. Researchers used several techniques to measure termite activity.

Underground monitoring station

At some sites, researchers replaced survey stakes with underground monitoring stations composed of a plastic collar containing a feeding block (Su and Scheffrahn 1986) (fig. 4A). Termite activity is quantified by measuring the wood weight loss of the feeding block. The monitoring stations also provide opportunities to conduct a mark-recapture procedure to identify the foraging range of the termite colony. In the Creole House of the Cabildo complex in New Orleans, for example, researchers collected workers of the Formosan subterranean termite from a station in the courtyard and stained them with a blue dye before releasing them back into the same station (fig. 5). During the follow-up inspection they found blue termites in the wooden floor of the second-floor office (Su et al. 2000).

Aboveground monitoring station

Soil was not always accessible. Therefore, researchers used an aboveground monitoring station similar to that described by Su et al. (1996) (fig. 4B) to measure the termite activity in some sites such as San Cristobal of San Juan National Historic Site.

Acoustic emission device

In addition to the monitoring stations, researchers used other methods such as acoustic emission detectors (AED) to measure termite feeding in wood (fig. 6). The detector recorded sound waves of ultrasonic frequency that were generated when termites broke wooden fibers. Researchers used the device to quantify termite activity in the wooden floor of the display case in the Statue of Liberty National Monument (Su et al. 1998), and in wooden beams of the Fort Christiansvaern of Virgin Islands National Park.

Figure 5. Termites marked with blue dye were released into a monitoring station to delineate colony foraging range.

Other methods of quantifying termite activity

At some historic sites, none of these tools could be used because of preservation concerns. For these sites, researchers counted the number of active monitoring stations and any other signs of termite activity. In Fort Christiansvaern of Virgin Islands National Park, for instance, researchers counted newly emerged foraging tubes of the subterranean termite *Heterotermes* sp. and removed them at each visit so that any new termite activity would be recorded.

Bait application

In some places where soil access was limited, researchers used aboveground stations (Recruit®AG), which consisted of a plastic box containing hexaflumuron bait (fig. 2B, page 19). Researchers attached the open-side of the Recruit AG bait box over an active infestation so that the bait was accessible to foraging termites. Researchers also experimentally constructed another type of aboveground bait station, the soft-style station, for use in several historic sites. This station consisted of a flexible plastic pouch containing hexaflumuron bait (fig. 2C, page 19) and, on its back side, a removable flap surrounded by flexible adhesive. Soft stations were attached over active infestations and the removable flap was pulled to expose the bait. Because of its flexibility, the soft station was adaptable to flat, curved, or contoured surfaces.

Figure 6. The acoustic emission detector (AED) recorded sound waves that were generated when wooden fibers were broken by termite mandibles, and was used to measure termite feeding in wood.

Effects of hexaflumuron baits on termite populations

Researchers measured termite activity at the Statue of Liberty National Monument (see fig. 3) using underground (T) and aboveground (AGM) monitoring stations. Additionally, they used three types of bait stations to deliver baits to termite populations, including the inground Sentricon station (S), the aboveground bait station, Recruit AG, (AGH), and the soft-style aboveground bait station (AGS). Termites fed on hexaflumuron baits as soon as researchers placed a bait station inside the display case in August 1996 (fig. 7, DIS). The acoustic emission device detected 20–30 feeding episodes per minute from the wooden floor of the display case through fall 1996 to spring 1997, during which *R. flavipes* continued to feed on the baits. By March 1997, no termites were found in the bait station, and the feeding activity in the nearby wooden floor also ceased.

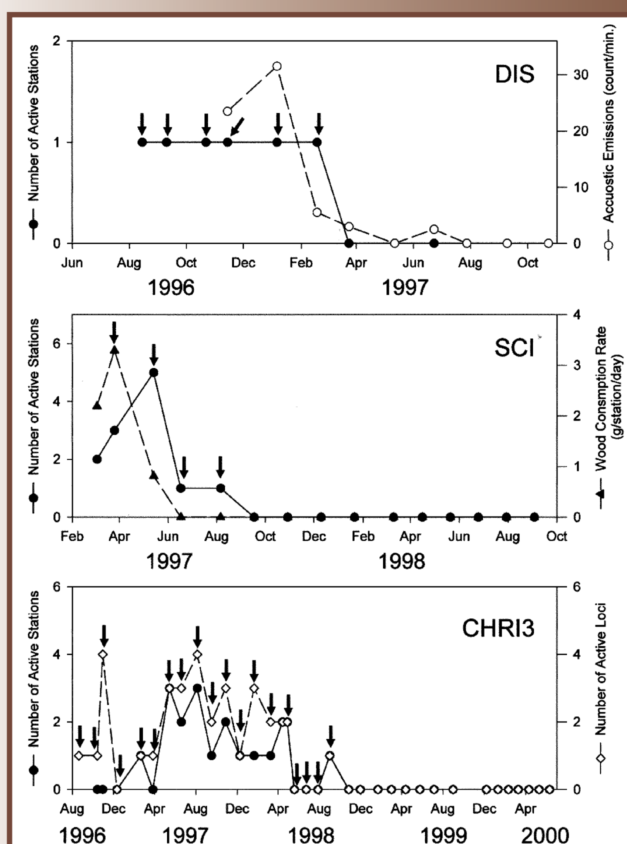


Figure 7. The researchers quantified termite activity as the acoustic emission count (per minute) in the display case of the Statue of Liberty National Monument (DIS), wood consumption rate (g wood per station per day) in the utility room of San Cristobal of San Juan National Historic Site (SCI), and number of active sites such as newly emerged foraging tubes of* Heterotermes *sp. in a storage room of Fort Christiansvaern, Christianstead National Historic Site (CHRI3). Arrows depict applications of hexaflumuron baits. Number of active stations was also included to measure the overall termite activity during and after bait applications.

In March 1997, the subterranean termite *Coptotermes havilandi* fed extensively on wooden blocks in two monitoring stations in the utility room of San Cristobal (fig. 7, SCI). In April, researchers applied hexaflumuron baits to these stations, and after one month, *C. havilandi* activity had declined significantly. By July no termites were found in the monitoring station. Slight feeding on hexaflumuron baits continued in July and August. During this time researchers found *C. havilandi* individuals in the bait station that exhibited apparent symptoms of hexaflumuron effects such as marbled coloration on the worker's abdomen. Since September 1997, no termite has been found in this location.

Unlike *Coptotermes* sp. that is more susceptible to hexaflumuron, the response of *Heterotermes* sp. in Fort Christiansvaern of the Virgin Islands National Park was more erratic. After the initial baiting in a storage room in August 1996, termite activity started to decline in December, but new activity emerged in spring 1997 (fig. 7, CHRI3). Despite repeated applications of baits throughout 1997, termites continued to feed on baits and new foraging tubes kept appearing. Our persistent efforts seemed to pay off when this second wave of termite activity ceased in spring 1998. The cessation lasted for three months, but in October 1998 termites reappeared in one bait station. This third wave of light activity, however, did not last as long as before. Researchers have found no termites or additional foraging tubes in this room since December 1998, two months after termites began feeding on hexaflumuron baits. The repeated cycles of activity during bait application appeared to be common for *Heterotermes* sp., which tend to have many small colonies in one area.

Monitoring and inspection

After successfully eliminating termite populations at a historic site, resource managers must establish a monitoring program to continue protecting the site from further termite infestation. At the Statue of Liberty National Monument, for example, Sentricon stations installed in soil surrounding the exterior wall of the monument have been monitored quarterly since 1998, and no termites have been found on Liberty Island. Termites are abundant in the tropics and subtropics. Even after successfully eliminating all detectable populations of *Heterotermes* sp. at Fort Christiansvaern, Virgin Islands National Park, re-infestation by neighboring populations is likely. To date, the routine inspections by Park Service personnel have not detected any new termite activity. If any sign of a new infestation is detected, the baiting program will resume to eliminate the new population before severe damage occurs.

Conclusions

National Park System sites and monuments are ideal environments for evaluating many new technologies for the preservation of cultural resources. Recent studies involving the use of baits containing the insect growth regulator, hexaflumuron, have demonstrated that they are safe and effective in protecting historic buildings and structures against subterranean termites with no adverse effect upon the cultural or surrounding natural resources. Moreover, the introduction of baits did not interfere with visitor services or the quality of the visitor experience at the sites or monuments.

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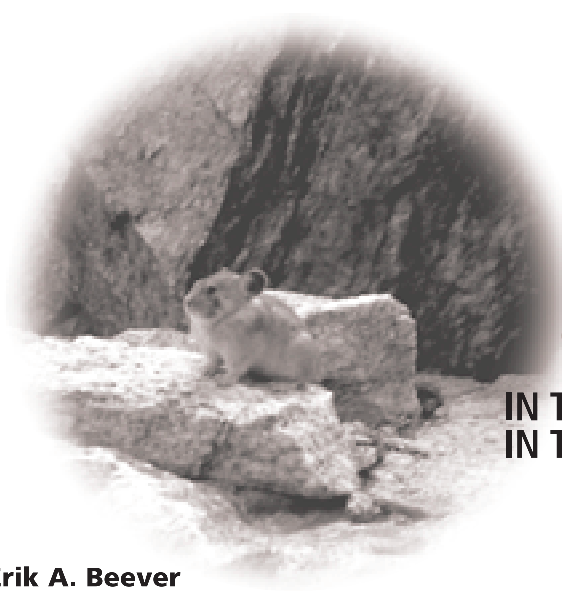

PERSISTENCE OF PIKAS

IN TWO LOW-ELEVATION NATIONAL MONUMENTS IN THE WESTERN UNITED STATES

By Erik A. Beever

From the perspective of island biogeography (MacArthur and Wilson 1967), national parks act as island reserves of restricted management sprinkled within a matrix dominated by commodity production and other human uses. Nonetheless, recent research has highlighted the dramatic changes (e.g., local extirpations, invasions of exotic species) that can occur in flora and fauna even on lands where the primary management mandate is resource conservation (Svejcar and Tausch 1991, Newmark 1995). The legacy of past disturbances, influences from adjacent lands, and climate change, in addition to the isolation and relatively small size of park units may all affect persistence of species within parks. In the western United States, pikas *(Ochotona princeps)* represent a model system that may help ecologists to understand these timely and complex relationships, as well as their implications for management in at least two units of the National Park System.

RELICTS OF A COOLER TIME

Pikas are small (100-175 g [4-6 oz]) mammals typically found in talus and other rocky habitats such as lava formations and mine tailings (fig. 1). Paleoecological evidence suggests that pikas were far more widespread during the late Pleistocene in western North America than they are today (Grayson 1987). Climatic warming during the past 10,000 years led to the extirpation of most low-elevation pika populations, producing the modern-day relictual distribution of the species. In the intermountain West currently pikas generally inhabit high-elevation areas and are considered montane mammals. However, temperature appears to limit their distribution more than elevation per se (Hafner 1993). For example, high temperatures (25.5-29.4°C [47.9-54.9°F] ambient shade temperature) can be lethal to pikas in as little as six hours, if they are caged on the surface of talus and thus deprived of their behavioral mechanisms to avoid stressful temperatures (Smith 1974). Consequently, pikas may be early sentinels of biological response to global climate change such as increased temperatures, although to date little fieldwork has been done on response of terrestrial vertebrates to climatic changes. Pikas' vulnerability to high temperatures partly results from the thick fur that insulates them against severe cold, because it also inhibits evaporative cooling during warm periods. A mystery remains, however, in whether acute (i.e., short-term) thermal stress, from high maximum temperatures, or chronic thermal stress over a pika's lifetime (resulting from living in hotter, drier climates) most affects pika persistence. Furthermore, as is true for most mammals, we know little about how thermal stresses interact with other potential stresses to pika populations such as small habitat area, catastrophic fires, human disturbance, and livestock grazing.

"Climatic warming during the past 10,000 years led to the extirpation of most low-elevation pika populations...."

Figure 1. Often heard but not seen, pikas typically inhabit high-elevation talus slopes in the western United States. However, the unusual occurrence of low-elevation pika populations in two western U.S. national monuments prompted the author to investigate their persistence and to evaluate implications for management of the species.

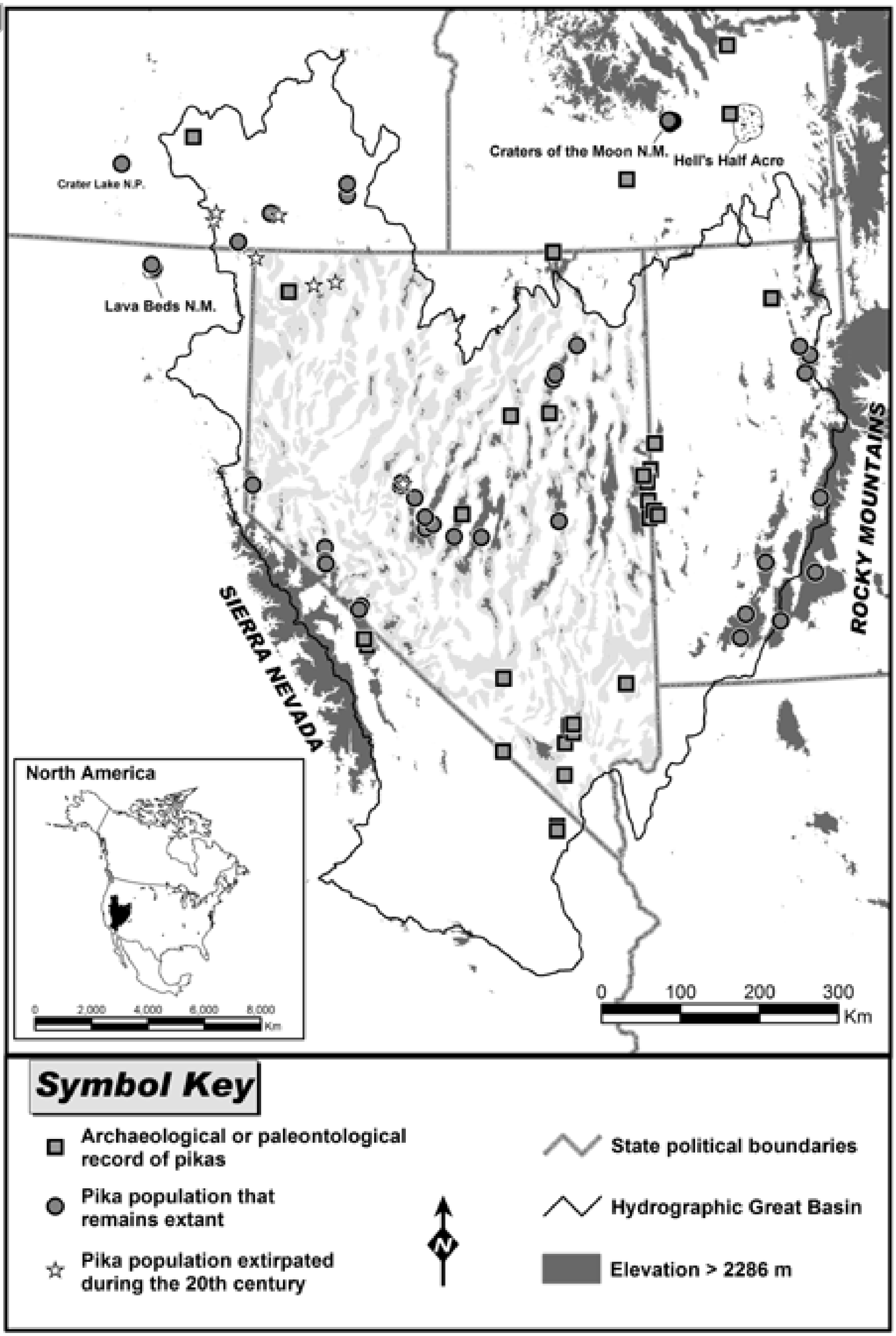

Figure 2. Pika surveys took place at 25 locations in the internally drained (interior) Great Basin; at Craters of the Moon and Lava Beds National Monuments where low-elevation populations of pikas persist; and at Hell's Half Acre, a low-elevation site near the monuments that lacks pikas but has similar habitat.

In the Great Basin (where precipitation drains internally rather than to an ocean; fig. 2), persistence of pika populations during the 20th century was significantly correlated with habitat area, elevation, longitude, distance to primary roads, latitude, grazing status, and management jurisdiction (wilderness vs. non-wilderness), but not with isolation of populations from the Sierra Nevada or Rocky Mountains (Beever 1999). Island biogeography theory predicts greater rates of extinction on islands (which may be oceanic or island-like pockets within continents) that are smaller in area and more isolated from the mainland, but does not make direct predictions about the other factors. Thus, the fact that isolation from Sierra Nevada or Rocky Mountain "mainlands" is not important in pika extirpations suggests that migration of pikas between mountaintop islands is not occurring currently. Rather, it appears that extirpation of populations from montane areas across the Great Basin is occurring without any concomitant colonization events. Average temperatures generally decrease with increasing latitude and elevation, thus latitude must be accounted for when assessing persistence at different elevations. Pikas at Craters of the Moon and Lava Beds National Monuments (hereafter, "Craters" and "Lava Beds") occurred historically at elevations lower than predicted by the monuments' latitude, when compared with the latitude-elevation relationship among historic pika sites in the Great Basin (fig. 3). Pikas do not usually persist at low elevations (and consequently, high temperatures), and many of the lowest-elevation populations in the Great Basin have recently become extirpated, including seven recorded from 1925 to 1941 (see fig. 3). For these reasons I sought to determine whether pika populations that had been noted historically in Craters and Lava Beds have continued to persist. If pikas had persisted, then I also sought to explore potential mechanisms that have allowed them to persist in such apparently harsh conditions.

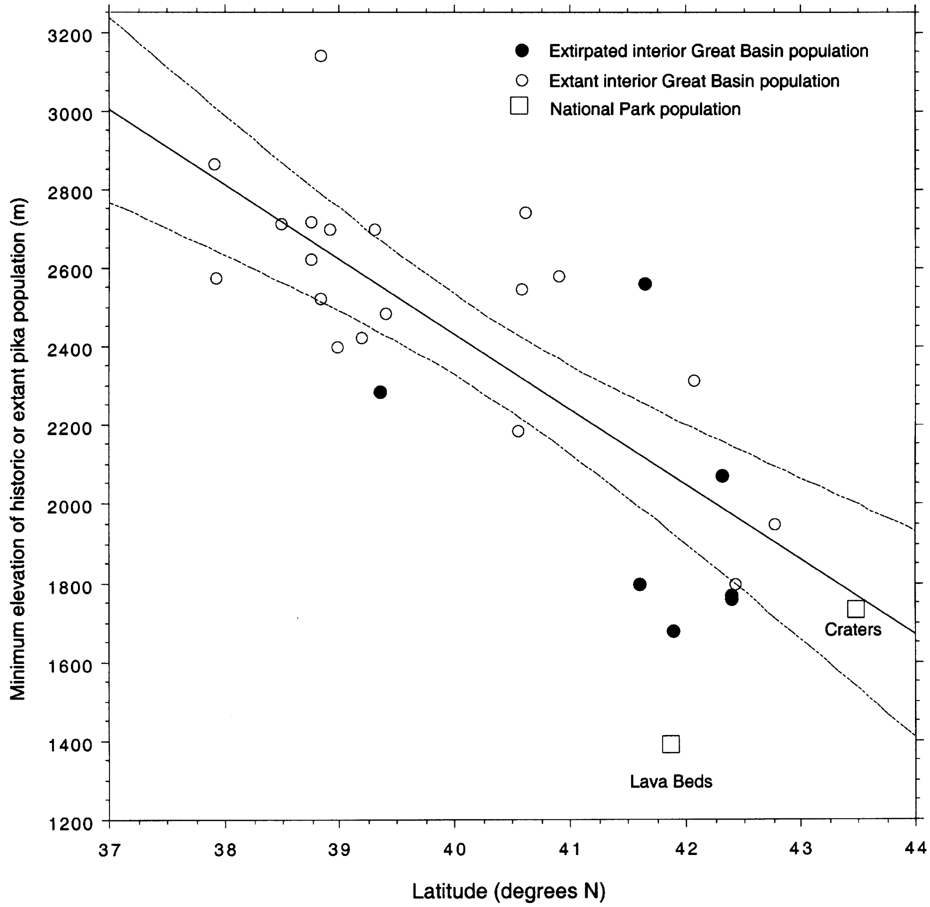

Figure 3. Persistence of pika populations during the 20th century in the intermountain West, at different elevations and latitudes. Open circles represent sites in the interior Great Basin where pikas remain extant, and closed circles represent pika populations that became extirpated in the late 20th century. Open squares represent Craters of the Moon and Lava Beds National Monuments, where pikas were recorded during the mid to late 20th century. The solid line represents the relationship between elevation and latitude among the 25 sites in the interior Great Basin at which pikas were previously recorded, and dotted lines represent 95% confidence intervals around the solid line.

STUDY SITES

Craters consists of 29,000 hectares (71,659 acres) of volcanic craters, cones, 2,000- to 15,000-year-old lava flows, caves, and fissures at the interface of the Snake River Plain and the southeast edge of the high, mountainous region of central Idaho (see fig. 2). Elevations in the monument ranged from 1,590-1,990 m (5,217-6,529 ft) at the time of sampling (1995), but the November 2000 expansion of the monument incorporated areas into the monument as low as 1,280 m (4,200 ft). Lava Beds occurs in northeastern California on the north flank of the Medicine Lake shield volcano that erupted 17 times between 800 and 12,800 calendar years ago (Donnelly-Nolan et al. 1990; see fig. 2). The volcano covers about 2,000 sq km (772 sq mi) and lies about 50 km (31 mi) east-northeast of Mt. Shasta in the southern Cascade Range. The monument's 18,850 ha (46,578 acres) occupy about 10% of the area of the volcano, and encompass cinder cones, spatter cones, and over 440 lava tube caves at elevations between 1,230 and 1,650 m (4,036 and 5,414 ft). Pikas are one of the more charismatic mammal species in the monuments, and are more frequently heard than seen. They are one of six lagomorph and 48 mammal species known from Craters, and one of three lagomorph and 53 mammal species known from Lava Beds.

To provide a comparison of a low-elevation area with extensive potential pika habitat that was geographically closer to the monuments than the interior Great Basin sites, I also sampled three locations in the Hell's Half Acre lava flow in south-central Idaho from 17–19 July (see fig. 2). We chose this site because it has extensive amounts of talus-like habitat, much of which occurs at large distances from primary roads; the site also has a similar range of elevations to Craters, but experiences different management. These factors played the most important roles in determining persistence of pika populations in the interior Great Basin during the 20th century. Because historic records of pikas in the vicinity of Hell's Half Acre do not exist, it would be difficult to ascribe a cause to the absence of pikas there, if we could not detect them. Ideally, other low-elevation sites outside but near either monument having historic records of pikas would have been preferable, but we were not aware of any such sites. In associated research, I also re-sampled populations of pikas recorded between 1916 and 1990 at 25 sites ranging in minimum elevation from 1,680–3,139 m (5,512–10,300 ft) throughout the interior Great Basin in summer from 1994 to 1999 (fig. 2).

METHODS

I re-visited locations in Craters from 14–17 July 1995 and in Lava Beds from 22–24 July 1995 where pikas had been observed in previous decades, and I sampled sites at Hell's Half Acre from 17–19 July 1995. Sampling occurred on lava formations for three days at each site (i.e., Lava Beds, Craters, and Hell's Half Acre), totaling between 15.5 and 18 hours of censuses per site. I chose specific sampling locations in the monuments based upon presence of precise historic records, relative accessibility, and the desire to sample broadly within each monument. Sampling at interior Great Basin sites occurred on taluses for 8 hours per site in summer between 1994 and 1999, or longer (up to 20 hr) if I could not detect pikas at the site.

During slow-walking transect surveys through lava formations, I recorded locations of pika sign (e.g., sightings, calls, and fresh hay pile sightings) using a handheld global positioning system unit without differential correction (precision ± 100 m [328 ft]). I used standardized recording criteria to avoid counting multiple types of evidence from the same individual. I also made observations on the natural history of pikas sighted within the monuments.

To compare climatic conditions at pika sites in the interior Great Basin and in the monuments, I used PRISM data (Oregon Climate Service, Corvallis) that interpolate values between climate stations across the region, and account for factors such as elevation and aspect. These estimated climatic values represent averages from the years 1961–1990, at a resolution of 4 km (2.4 mi). I compared annual precipitation and averages of the maximum daily temperatures for the months of June, July, and August among sites in the interior Great Basin where pikas have been extirpated recently, sites in the Great Basin where they remain extant, and the three volcanic sites (Craters, Lava Beds, and Hell's Half Acre) adjacent to the Great Basin.

RESULTS

Persistence

In Lava Beds, I detected a minimum of 10 pikas (6 sightings, ≤4 calling individuals) from 9 sites, out of 16 sites visited (table 1). Pikas were detected at five of nine sites very near to where they were documented in monument records (1960–1991), and at four of eight sites more distant from historic locations. In Craters, I detected a minimum of 27 pikas (8 sightings, ≤ 18 calling individuals, and one active hay pile) at 8 of 12 sites visited. Pikas were detected at four of five historic locations (and an inactive hay pile was found at the fifth location), and at four of seven sites slightly more distant from historic locations. No pikas were detected at any of seven locations searched within Hell's Half Acre.

Climatic analyses

Loss of pika populations at study sites in the interior Great Basin occurred at sites that were on average 20% drier and 8–10% warmer than those at which populations persisted (table 2, page 28). However, the Craters and Lava Beds Monuments, where pikas persist, experience climates that are an estimated 18–24% drier annually and 5–11% warmer during the hottest months of the year than climates at areas of even *extirpated* pika populations in the interior Great Basin (table 2). Hell's Half Acre, from which pikas are not known in recent times, received an estimated average of 22–28% less precipitation annually and experienced temperatures 3–5% hotter than Craters and Lava Beds.

Natural history

Other mammals observed in Craters lava fields included chipmunks, yellow-bellied marmots, and golden-mantled ground squirrels. From my observations in Craters, pikas apparently use different parts of the volcanic landscape than chipmunks and squirrels, at least during summer. Whereas ground squirrels and chipmunks are more frequently found on flatter areas with less complex relief (usually *pahoehoe* or short *aa* lava formations or areas with extensive sagebrush vegetation), pikas appear to frequent lava tubes, caves, and valley trenches 2–5 m (6.6–16.4 ft) deep. I observed several mountain cottontails along margins of lava flows in Lava Beds, but did not observe them well within the lava flow, where pikas were often seen. Although other mammals were less plentiful at Hell's Half Acre, birds were relatively more abundant.

Although pikas in the monuments dedicated significant amounts of time to vigilance, numerous individuals were less responsive to the presence of nearby humans than were pikas at sites in the interior Great Basin. Whereas I could never approach pikas to a distance less than 13–15 m (42.6–48.2 ft) in the interior Great Basin, I came within 20 cm (8 in) of stepping on one at Craters. Furthermore, one individual on the Devil's Orchard Trail seemed so habituated to humans that it remained above the lava surface for 5–8 minutes when a group of about 25 relatively boisterous visitors approached it to within 10 m (33 ft).

DISCUSSION

Persistence of low-elevation pikas: climatic and other influences

Loss of pika populations from lower elevations and latitudes, such as the loss of nearly 30% of interior Great Basin popula-

Table 1: Locations sampled for pikas in Lava Beds and Craters of the Moon National Monuments, July 1995.

	Location	Elevation (m)	Search effort (hr)*	Date of historic record, if available	Pikas detected in 1995 survey?
LAVA BEDS	Heppe Ice Cave	1610	0.75	1991	No
	Catacombs parking lot	1525	2.00	1961, 1962	Yes
	Juniper Cave	1510	0.50	1960	No
	Catacomb Cave, upper Sentinel entrance	1490–1525	2.50 [3]	1963	Yes
	Maze Cave collapse	1490	1.00 [2]		No
	Merrill Ice Cave	1490	1.50	1962	Yes
	Thunderbolt Cave, upstream entrance	1490	0.25	1990	No
	Lower Sentinel entrance	1475	0.75 [3]		Yes
	Indian Well Cave	1450	0.50		Yes
	Symbol Bridge	1440	1.00 [3]	1972	Yes
	Skull Cave road	1400	1.00		No
	Fleener Chimneys area	1365	0.75	1984	Yes
	Schonchin Lava Flow	1340	1.00		No
	Trail to Black Crater; Battlefield Trail	1340	0.75		Yes
	Devil's Homestead Lava Flow	1280	0.50		No
	TOTALS (N = 15 sites, 22 searches)	Mean = 1450 m	16.0 hr		10 individuals
CRATERS OF THE MOON	North Crater Flow trail	1830	2.00	1990	Yes
	Base of North Crater	1830	1.25		Yes
	Scenic turnout near Spatter Cones parking lot	1830	1.00		No
	Highway Flow	1810	4.00 [2]		No
	Spatter Cones, trail to Big Crater	1810	2.25		Yes
	Trail to Buffalo Caves	1790	0.75		Yes
	Picnic table turnout	1780	1.00		Yes
	Base of Big Sink, Tree Molds Road	1780	0.75		Yes
	Jct of main loop road and Tree Molds road	1780	0.50	1990	No
	Caves Area Trail to Needles Cave	1760	3.25		Yes
	Devil's Orchard Trail	1750	3.25	1989, 1990	Yes
	Caves Area Trail	1750	2.25	1991	Yes
	TOTALS (N = 12 sites, 13 searches)	Mean = 1790 m	18.5 hr		27 individuals

* Number of searches (if >1) appear in brackets

tions recorded during the 20th century, is consistent with losses that have occurred over the last 14,000 years (Grayson 1993). Given the recent extirpation of pikas from low-elevation sites within 150 km (93 mi) of Lava Beds (Beever 1999; fig. 2), current persistence of pikas in Craters and Lava Beds National Monuments is noteworthy. Although population losses in the Great Basin occurred not surprisingly at sites that were drier and warmer than those at which populations persisted, estimated climates at Lava Beds and Craters were notably drier and hotter than even those locations in the Great Basin where pikas have been recently extirpated. However, the tubes, caves, and deep, complex lava formations that occur across both monuments undoubtedly provide pikas with relatively cool refugia during times of heat stress. Interestingly, though, pikas were not exclusively confined to caves and lava tubes during my July surveys, suggesting that temperature influences provide only a partial solution to the mystery of how pikas persist in these monuments. Pika behavior plays a substantial role in mediating the

Table 2. Estimated climatic conditions at areas in the interior Great Basin where pikas remained extant and where they were extirpated during the 20th century, and at two low-elevation national monuments adjacent to the Great Basin that still contain pikas.

Site(s)	Elevation range*	Average annual precipitation (cm/yr ± 1 SE [standard error])	June maximum temperatures** (°C)	July maximum temperatures (°C)	August maximum temperatures (°C)
Sites (N = 18) in the interior Great Basin with extant pika populations	1,798–3,612 m (5,900–11,850 ft)	58.9 ± 6.2	19.3 ± 0.7	24.7 ± 0.6	24.8 ± 0.5
Sites (N = 7) in the interior Great Basin with extirpated pika populations	1,680–2,877 m (5,512–8,600 ft)	47.4 ± 7.0	21.3 ± 0.5	26.6 ± 0.6	26.7 ± 0.5
Lava Beds National Monument	1,230–1,650 m (4,036–5,414 ft)	36.1	23.6	28.6	28.2
Craters of the Moon National Monument	1,590–1,990 m (5,217–6,529 ft)	38.8	23.5	29	28.1
Hell's Half Acre	1,400–1,630 m (4,593–5,348 ft)	28.1	24.4	30.1	29.0

*Represented are the lower end of talus at the lowest sites in each category (lowest elevation currently with pikas, for the lowest site with an extant population in the interior Great Basin), and the highest elevation of talus habitat within 3 km of the location of the historic record of pikas (among all sites in the group).
**Average of daily maximum temperatures for days in June (values indicate average ± 1 SE when >1 site).

effects of thermal stress, and measuring temperature regimes that pikas experience throughout the day and across seasons may provide another clue to understanding how they persist in these low-elevation areas.

"Pika behavior plays a substantial role in mediating the effects of thermal stress…."

In both monuments, pikas apparently use habitats that fulfill three requirements. First, pikas generally inhabit large, contiguous areas of (rocky) volcanic habitat, as opposed to isolated pockets of lava formations. Second, although pikas were not always located near edges of lava flows, areas with pikas possessed average or greater amounts of vegetation accessible within distances comparable to dimensions of home ranges. Finally, pikas appeared to be associated at the fine scale with microtopography characterized by rocks large enough to provide space for subsurface movement and tunneling (as is found in *aa* and block lava flows), as opposed to the smooth *pahoehoe* lava flows that have little relief. Because collapsed lava tubes, lava flow margins, cave entrances, fault scarps, fault cracks, and internal talus zones all provide talus-like areas that pikas may inhabit, geologic mapping of the monuments may provide additional insight into pika distribution.

In contrast to our relatively clear understanding of the climatic effects on pika distribution, the exact extent to which human-related activities such as livestock grazing, altered fire regimes, clear-cutting of adjacent forest cover, and other influences on lava habitats affect pika population dynamics remains in need of clarification. While the systems of caves and lava tubes have undoubtedly facilitated persistence of pikas in the monuments, other factors that may contribute to their persistence in these low-elevation areas include: extensiveness and connectivity of lava habitats, relatively close proximity (30–80 km [18.6–49.7 mi]) to other known pika strongholds (Hafner 1994; J. Villegas, 2001, personal communication), physical complexity of lava formations, relative inaccessibility for humans, and wilderness management. Although Hell's Half Acre possesses extensive lava flows, amounts of vegetation comparable to that of Craters, proximity (<130 km [80.7 mi]) to three other pika populations, and is relatively inaccessible over much of its area, it has fewer caves and lava tubes, a less convoluted lava structure, and a hotter, drier climate than Craters; and it is managed as a multiple-use recreational area.

This research does not allow conclusive understanding of to what degree the effects of wilderness management, habitat extent, and physical structure of habitats have contributed to persistence of monument populations of pikas while other low-elevation (interior Great Basin) populations have suffered extirpation. Although manipulative experiments, which provide stronger inference about cause-effect relationships, are not feasible within the monuments, two avenues of observational research may prove fruitful. Broad sampling for pikas in numerous caves and tubes within and around the monuments would afford greater understanding of the range of conditions (with respect to temperature, humidity, cave size and habitat extent, isolation from other populations, and human activity) that support pika populations. During sampling, collection of tissue samples from individual pikas would allow comparison of genetic differences among known pika populations and would suggest relative rates of gene flow among them. Correlation of genetic results with potentially isolating features (e.g., roads, surrounding non-talus habitat, different systems of lava tubes) and management actions (livestock grazing, fire frequency) would provide a basis for generating hypotheses as to which factors, if any, have constrained pika distribution.

MANAGEMENT IMPLICATIONS

Persistence of pikas, at least in the interior Great Basin, appears to be a function of extent of habitat, distance to primary roads, and maximum elevation of habitat to which pikas can migrate (which should dictate pikas' ability to respond to climate change) (Beever 1999; Beever et al. forthcoming). Additionally, pika population size relates to the presence of livestock grazing in some cases (Beever 1999; Beever et al. forthcoming). Therefore, management actions may hold great importance for pika persistence. For most species, persistence depends critically on the amount, spatial distribution, and quality of appropriate habitat. Although removal or physical degradation of lava and talus habitats are not likely over ecological time scales, habitat quality for pikas may be compromised by the following: consistently higher ambient temperatures (e.g., due to climate change); altered composition of forbs and grasses in and adjacent to lava flows (e.g., because of altered fire regimes, exotic species, or uncharacteristically intense levels of grazing at flow margins); and significant fragmentation of lava habitats (e.g., road construction). Pika persistence at low-elevation sites may also be affected by disturbance or alteration of pika habitats by humans or livestock (e.g., nutrient deposition by livestock in large caves [J. Villegas, 2001, personal communication], human disturbance of hay piles). Because human disturbance of lava flows to this point has been confined primarily to areas near roads or trails during warmer months, these latter influences probably have been minimal.

Isolation of Great Basin pika populations from the Sierra Nevada or Rocky Mountains is one of few variables that does not predict persistence in the Great Basin. This phenomenon probably occurs because talus habitats in the Great Basin are separated by vast areas of non-talus habitat that usually lie at low elevation, and pikas are unlikely to traverse these areas under current climatic conditions. In contrast, the recent ninefold expansion of Craters' area creates the possibility for promoting pika persistence across the more continuous lava habitats along the Great Rift, to the extent that the monument explicitly manages for vertebrate conservation. Although connectivity among volcanic habitats may not change with monument expansion, changes in management in the area may alter *effective* connectivity. Thus, although Newmark (1995) concluded that national parks in western North America are too small to support viable populations of large mammals, actions such as monument expansion and others described earlier may help prevent loss of noteworthy pika populations from these low-elevation monuments.

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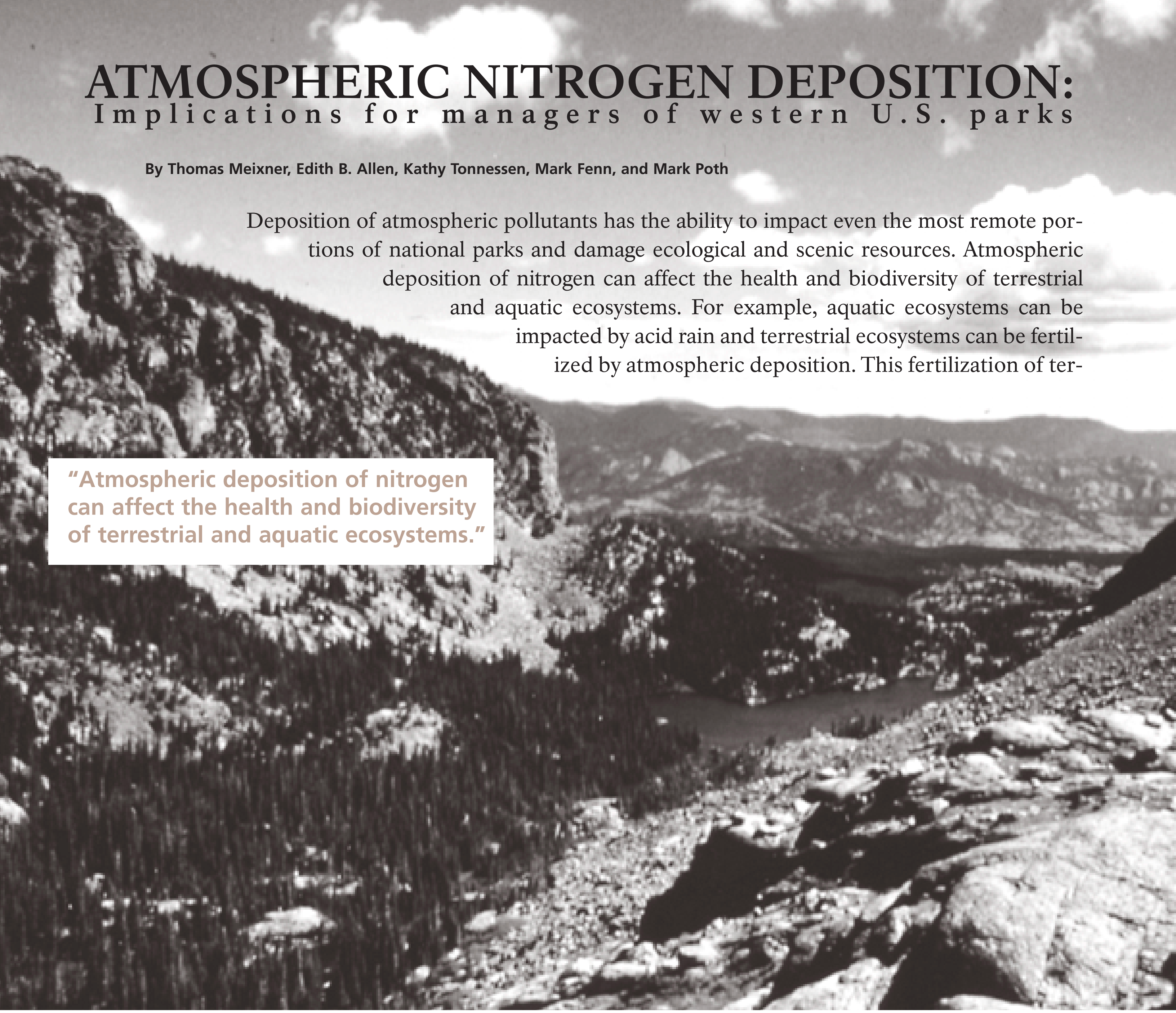

ATMOSPHERIC NITROGEN DEPOSITION:

Implications for managers of western U.S. parks

By Thomas Meixner, Edith B. Allen, Kathy Tonnessen, Mark Fenn, and Mark Poth

Deposition of atmospheric pollutants has the ability to impact even the most remote portions of national parks and damage ecological and scenic resources. Atmospheric deposition of nitrogen can affect the health and biodiversity of terrestrial and aquatic ecosystems. For example, aquatic ecosystems can be impacted by acid rain and terrestrial ecosystems can be fertilized by atmospheric deposition. This fertilization of terrestrial ecosystems may in turn lead to decreases in biodiversity. Also, leaching of large quantities of nitrate from terrestrial ecosystems into streams might impact aquatic ecosystems through eutrophication (i.e., nutrient enrichment in places like Lake Tahoe, for example) or possibly by direct toxicity to fish and amphibians.

> "Atmospheric deposition of nitrogen can affect the health and biodiversity of terrestrial and aquatic ecosystems."

The impact of nitrogen deposition on terrestrial and aquatic ecosystems depends on a number of variables, including meteorological variability, vegetation type, historical land use, fire history, hydrology, and proximity to the pollution source. In the eastern United States research on atmospheric deposition has generally focused on the problems of acid rain and its impacts on terrestrial and aquatic ecosystems. The problems in the East tend to be more widespread than in the western United States and while many of the issues are similar in the two regions there are differences that prevent simple extrapolation from one ecosystem to the other. This report will focus on western systems since they have historically not been studied as much as the more humid systems typical of the eastern United States. Ongoing research in three different western U.S. ecosystems—alpine lakes and tundra in the Front Range of the Rocky Mountains and the Sierra Nevada, conifer forests in southern California, and the coastal sage scrub of southern California—is examining nitrogen deposition and its varied impact on these systems. While these ecosystems are by no means ubiquitous, they do have analogs throughout the National Park System and the United States.

Impacts on western U.S. ecosystems

A comparison of alpine ecosystems in the Rocky Mountains and in the Sierra Nevada and their different exposures and responses to atmospheric deposition can provide insight into how factors such as ecosystem biomass, proximity to urban areas, and meteorology affect ecosystem sensitivity to nitrogen deposition. Alpine ecosystems are sensitive to nitrogen deposition because very little soil and only sparse vegetation exists to cushion the impacts of atmospheric deposition. The alpine zone of the eastern slope of the Front Range of the Rocky Mountains appears to have been impacted by changes in atmospheric deposition, with stream nitrate concentrations much higher than on the western slope of the Rockies. In contrast, the alpine zone of the Sierra Nevada has exhibited no significant change in ecosystem dynamics or in stream water quality despite the proximity of large cities in California to the mountains. The lack of summer rain originating from polluted air masses in the Sierra Nevada and the stable inversion over the Central Valley of California limit nitrogen deposition in the alpine zone during the summer months. Much of the precipitation in the Sierra Nevada is winter snow that comes from clean, Pacific air masses that have limited interaction with industrial or urban areas. The Front Range of the Rockies appear to have higher rates of nitrogen deposition than the Sierra Nevada alpine zone. In part, this is because of its proximity to the Denver metropolitan area in combination with more summer rain. These factors encourage the deposition of pollutants from the urban air mass (fig. 1). Also, dry deposition of nitrogen is likely limited in the Sierra Nevada compared to the Front Range because this form of atmospheric deposition decreases rapidly as distance from the source increases. Nevertheless, although the alpine zone of the Sierra Nevada is not currently being impacted by nitrogen deposition, impacts may be occurring in the lower conifer and chaparral zones of the range. These areas are experiencing much higher dry deposition rates than the alpine zone.

"Factors such as ecosystem biomass, proximity to urban areas, and meteorology affect ecosystem sensitivity to nitrogen deposition."

Figure 1. The Loch Vale watershed in Rocky Mountain National Park, Colorado, has played a prominent role in understanding the impact of nitrogen deposition on ecosystem dynamics. The Font Range of the Rocky Mountains appears to be more affected by nitrogen deposition than the Sierra Nevada on account of thunderstorms that feed on air from the Denver area.

Figure 2. The high amount of biomass and winter-dominated hydrology of conifer forests in California appear to reduce the forest's short-term susceptibility to nitrogen deposition.

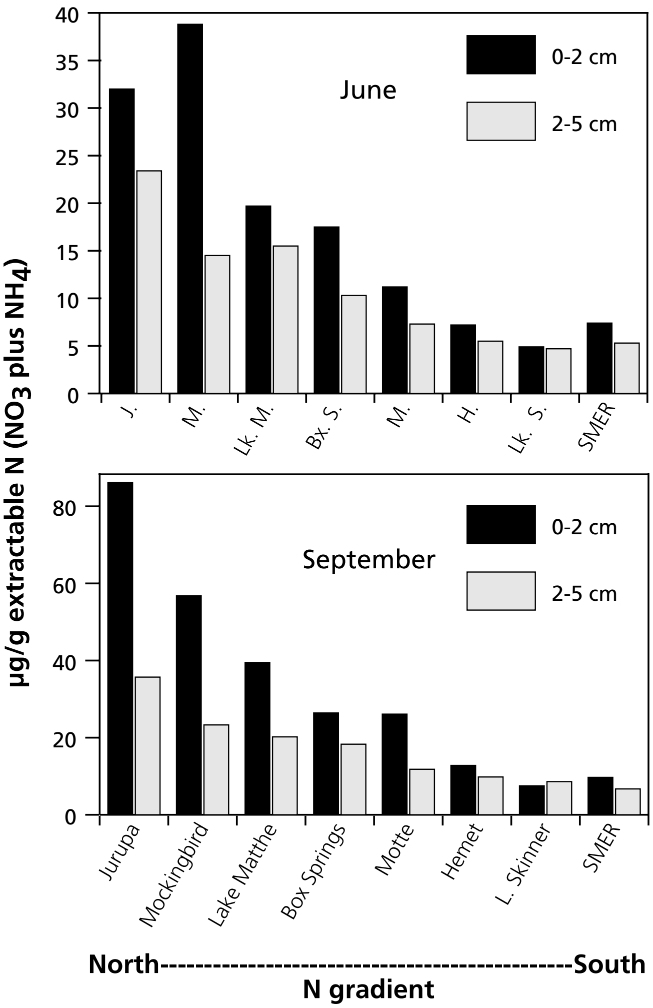

Figure 3. Soil nitrogen gradient in sites lying north to south in the coastal sage scrub ecosystem of the Riverside-Perris Plain, California. Biodiversity at these sites is inversely proportional to nitrogen concentrations in the soil with the highest biodiversity at the southern (low concentration) end of the gradient and the lowest biodiversity at the northern (high concentration) end of the gradient.

Conifer forests demonstrate the importance of hydrological and meteorological processes and ecosystem biomass on ecosystem sensitivity to nitrogen deposition (fig. 2, page 31). In contrast to the sensitivity of alpine ecosystems, the ponderosa and Jeffrey pine forests of southern California appear to be fairly resistant to increases in atmospheric nitrogen deposition at least in the short term. This resistance is despite the 30–40 kg nitrogen per hectare (163–217 lb/acre) per year that the most exposed forests receive (compared to about 2 kg/ha [11 lb/acre] in the alpine Sierra Nevada and 4–8 kg/ha [22–43 lb/acre] in the alpine Front Range). The interaction between hydrology and plant physiology appears to control the susceptibility of this ecosystem to nitrogen deposition. Summertime dry deposition of particulates and nitrogen-based gases dominate deposition in this ecosystem. Winter rains, which arrive when the vegetation is generally dormant, flush the atmospheric deposition rapidly off the vegetation and out of the soil, sending a large pulse of nitrate into the streams of the San Bernardino and San Gabriel Mountains. When trees become active again in spring much of the nitrogen available to the plants has been leached out. The high rates of atmospheric deposition have increased plant nitrogen uptake, and physiological functioning has been altered by increased nitrogen deposition in these systems. Despite these changes fertilization experiments show that the vegetation will still respond to additional nitrogen. Conifer forests might also be more resistant in the short term because of the relative long life of conifer trees. These conditions indicate that nitrogen deposition is having a slower, less visible impact on the terrestrial component of the conifer ecosystem than it is on nearby aquatic systems.

Coastal sage scrub ecosystems may be among the most sensitive terrestrial environments because of their relatively *closed* hydrology and low biomass. Nitrogen deposition has been implicated in the replacement of native grasses and shrubs by invasive grasses, which have led to a decrease in biodiversity in areas of southern California previously dominated by coastal sage scrub vegetation (figs. 3 and 4). Coastal sage scrub is especially susceptible to nitrogen deposition on account of dry summers when nitrogen deposition is highest and nitrogen accumulates, followed by moist, relatively warm winters when the accumulated nitrogen becomes available for the growth of native and exotic species. Unlike the conifer forests, sage scrub is biologically active during winter, and plants rapidly respond to the onset of winter rains with the growth of shrubs, annual forbs, and grasses. Low rainfall in the coastal sage scrub accounts for very little nitrogen leaching out of the root zone of most vegetation. Thus, atmospherically deposited nitrogen in soil is available throughout the winter growing season. The exotic grasses are biologically designed to take advantage of the excess nitrogen, while

Figure 4. This coastal sage scrub site near Riverside, California, has been degraded by atmospheric nitrogen deposition. Note smog in the background.

the sage scrub has lower rates of nitrogen uptake. Exotic grasses are prolific seed producers and have an increased fire cycle. These factors along with increased productivity from nitrogen deposition are allowing exotic grasses to replace the native sage scrub.

Susceptibility of ecosystems

These three case studies allow us to derive a number of rules of thumb about the susceptibility of natural ecosystems to nitrogen deposition in the near future. (In the long run, if nitrogen deposition continues, all of these ecosystems will likely change.) The closer an ecosystem is to a large city the greater the likelihood for ecosystem damage from nitrogen deposition (e.g., Front Range of the Rockies and coastal sage scrub). Ecosystems dominated by storms originating at sea that do not move through major urban or industrial areas are less susceptible to nitrogen deposition (e.g., the Sierra Nevada, fig. 5). Terrestrial ecosystems that are dormant during the peak time of nitrogen availability are less susceptible to the impacts of nitrogen deposition, whereas aquatic ecosystems might be more susceptible (e.g., the conifer forests of southern California). Ecosystems with high biomass (e.g., conifer forest) are less susceptible to nitrogen deposition than those with low overall biomass (e.g., alpine tundra and coastal sage scrub). Ecosystems with low rainfall (e.g., coastal sage scrub) are more susceptible to the effects of nitrogen deposition than systems with relatively high rainfall rates (e.g., southern California coniferous forests) because the nitrogen is not substantially flushed out of the root zone of most plants.

Implications

Work remains on the occurrence and susceptibility of ecosystems to atmospheric nitrogen deposition. Still, enough evidence has been compiled for managers to be concerned about the possible impacts of nitrogen deposition on the natural resources of our western national parks. Western U.S. problems with nitrogen deposition are more localized in areas impacted by urban air masses. Thus these problems differ from the more widespread, and in some cases more severe, problems present in eastern national parks such as Shenandoah and Great Smoky Mountains National Parks. In particular, managers of western national parks near urban areas (e.g., Rocky Mountain, Sequoia-Kings Canyon, Joshua Tree, Yosemite, and Saguaro National Parks and Santa Monica National Recreation Area) should be aware of issues involving atmospheric deposition, and resource managers should be encouraged to spend their time and funds on studying this issue. The types of studies that might be done to understand the susceptibility of ecosystems to nitrogen deposition include water quality monitoring in the parks over a number of years, measurements of soil or litter carbon:nitrogen ratios, and monitoring of vegetation to investigate nutrient ratios of standing vegetation.

"Resource managers should be encouraged to spend their time and funds on studying [nitrogen deposition]."

Figure 5. Researchers conduct a survey of the quantity and quality of snow in the Emerald Lake watershed in Sequoia National Park. Sierra Nevada alpine watersheds appear to be unaffected by atmospheric deposition due to the clean, marine-air origin of much of the precipitation in the range.

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An innovative training program enhances science-based management

By Kathleen Kodish Reeder

Figure 1. Formed during the last Ice Age, kettle ponds are a primary resource of Cape Cod National Seashore. One of the first participants of the Natural Resource Professional Development Program, Krista Lee, studied the geochemical processes that influence water quality of the ponds.

The Northeast Region's FY 2001–2005 Natural Resource Challenge plan emphasizes that information derived from rigorous scientific research is the best foundation for making management decisions affecting natural resources. Many natural resource managers are working to make their parks centers for broad scientific and scholarly inquiry by using science-based standards to determine the condition of their natural resources, and to evaluate the success of resource preservation and restoration strategies. Accordingly, the Northeast Region (NER) has established agreements with scientists at universities and research agencies such as the U.S. Geological Survey to conduct research in the parks. In many instances, however, natural resource managers believe that they can implement science-based management most effectively by improving the level of scientific expertise within the parks.

In 1998 this belief led the Northeast Region to create an ongoing program designed to support two National Park Service (NPS) employees, one from the New England Cluster and the other from the Chesapeake-Allegheny Clusters, in their pursuit of an approved, graduate-level course of study in the natural and physical sciences. According to Marie Rust, Regional Director, "It is our intent, through this Natural Resource Professional Development Program [NRPDP], to enhance the natural resource academic credentials and skill levels of our region's resource managers so that we will have the ability to effectively resolve the many complex issues threatening our park resources." Once a participant has completed the development program, new applications are accepted from that cluster for the subsequent fiscal year.

Program profile

Participants, who must be permanent park or support office employees, are competitively chosen by a panel comprising regional and park natural and human resource professionals. While individuals may pursue advanced training in any of the natural or physical sciences, certain academic disciplines are given priority: hydrology, limnology, coastal geology, fisheries biology, aquatic ecology, botany, forestry, and wildlife ecology. In the essay that accompanies the application, applicants describe their previous or current graduate-level courses and explain the field of study or research (if appropriate) they would pursue. If selected for the program, they sign an agreement that formally describes their objectives and stipulates the length of time that they are expected to continue working for the National Park Service after training (typically time equal to the length of participation in the program). To remain in the program, individuals must maintain a "C" grade point average; employees who fail to complete the program or meet any of the other requirements are liable for the full cost of any funds received while participating in the program. Since the purpose of facilitating advanced education is to raise the staff's level of scientific expertise, the review panel gives priority to individuals who show promise, but have limited or no experience designing or supervising research studies involving natural resources in the parks.

According to Mary Foley, Regional Chief Scientist of the Boston Support Office, the Natural Resource Professional Development Program offers the flexibility and financial support that make pursuing advanced study more feasible than traditional post-graduate or training options. For example, the regional Natural Resource Program provides each participant up to $25,000 per year to cover the costs of tuition, books, or research activities while the employee continues to receive regular pay and benefits. After completion of training or study, the employee returns to his or her duty station. The training objectives are individually designed by the selected applicant, his or her supervisor, the support office chief scientist, and the appropriate university faculty so that the skills being acquired (and even the research activities themselves) can complement the park's natural resource goals. Within the parameters of the program (a maximum of three consecutive years), the natural resource professional and his or her park manager can determine the best schedule for the employee and the park, resulting in a variety of possible combinations of part- or full-time study and regular duty. Negotiations can also result in unused program funds being made available to the applicant's park if they are needed to fill the vacated position while the participant is in training.

With the recent completion of the program by the first two participants, it has already become clear that there is a strong "return-on-investment" on several levels. The knowledge and experience acquired by these graduates have shown that the program can benefit not only the individuals and their respective parks, but also the National Park Service as a whole, and many of the agencies and institutions that are their partners in natural resource conservation.

Cape Cod case study

Krista Lee, a chemist with the North Atlantic Coastal Laboratories at the Cape Cod National Seashore (Massachusetts), was accepted into the development program in fall 1998 and concluded her studies in December 2000. Ms. Lee's course of study included earning 32 credit hours at Boston University and writing her master's thesis in earth sciences with a concentration in environmental geochemistry. When she was not in classes or conducting field research, she was working at her position with the National Park Service. The motivation for her research was the need to analyze the geochemical processes that influence the water quality of the cape's freshwater kettle ponds. These ponds, formed during the last Ice Age, are a primary and unique natural resource at Cape Cod National Seashore.

To understand the influence of groundwater on the kettle ponds, Ms. Lee needed a basic understanding of Cape Cod's hydrologic budget. In this phase of her research she employed mathematical hydrologic modeling and GPS (global positioning system) technology to assess the local hydrologic setting around two of the ponds. Duck Pond, an isolated basin primarily influenced by precipitation and groundwater, and Gull Pond, which is stream-fed, were chosen by Ms. Lee because their differences offered the opportunity to learn the effects of several variables on kettle pond geochemistry (fig.1).

"To understand the influence of groundwater on the kettle ponds, Ms. Lee needed a basic understanding of Cape Cod's hydrologic budget."

In order to analyze the water quality of both sites and the surrounding groundwater, Ms. Lee quantified trace elements by using a spectroscopy technique that reveals very low levels of elements in the samples based on the light energy those elements emit. Ms. Lee identified the nutrients present in the pond water and groundwater by conducting flow injection analysis, a technique that uses color chemistry to indicate levels of nutrients in the samples. Identifying the primary internal and external sources of nutrients yielded the "nutrient budget" of the ponds. Knowing how to determine the typical annual budget for a pond will be helpful in determining the source and impact of nutrients and trace elements on the ponds in the future.

Ms. Lee's advanced studies have already benefited Cape Cod National Seashore because they quantify the trace elemental and nutrient levels of the surrounding groundwater influencing the ponds. Since the quality of the kettle ponds will be affected by future development and visitor use, managers must have the ability to monitor groundwater and pond water changes. With her new analytical skills, Ms. Lee will be able to participate in ongoing monitoring programs and new initiatives, as well as recommend strategies to address external threats, such as septic tank leaks. According to Ms. Lee, "I can now provide additional analytical and technical assistance to park management regarding water quality issues, and I have learned a bit about the hydrologic processes that influence the ponds on the cape." She has begun sharing both her research findings and the techniques she has learned by attending professional conferences and making presentations.

Assateague Island case study

The effectiveness of the development program has also been evident in the accomplishments of Christopher Lea, a plant ecologist at Assateague Island National Seashore (Maryland). In 1994, Mr. Lea, a full-time National Park Service employee, began using his personal time to take courses and gather field data to earn his Master of Science degree at George Mason

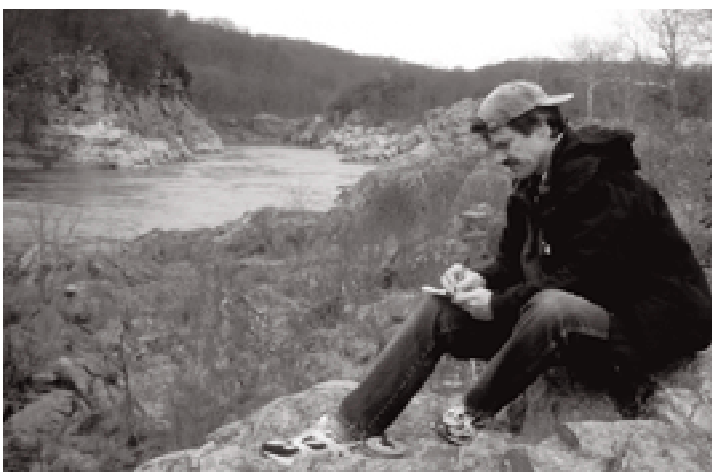

Figure 2. An early participant in the Natural Resource Professional Development Program, plant ecologist Chris Lea of Assateague Island National Seashore described the relationship between the plant communities near the Potomac River Gorge and the flooding of the river. Part of the project involved recording data on bedrock cover on South Bear Island, which floods every five to ten years on average.

University in Fairfax, Virginia. When the Northeast Region created its professional development program in 1998, Mr. Lea applied for the program to facilitate completing the last stage of his studies. From August 1998 (when he was accepted in the program) until April 2000, he continued to work for the National Park Service while taking his last required course, analyzing data, and writing his thesis. Although he most likely would have completed the requirements for a degree without NRPDP assistance, the program (combined with other resources) alleviated educational expenses and enabled him to expedite his studies and conduct a research effort that was much more sophisticated and challenging than a typical research project at the master's level.

"His study ... examines fluvial environmental effects on vegetation by directly measuring flooding frequency and ... measure[s] the effect of river energy as a factor affecting riparian vegetation."

Mr. Lea's master's thesis reflects his desire to understand ecological theory and to apply his research to the resolution of park conservation issues. His two objectives were to describe the nature of the relationship between the vegetation (plant communities) near the Potomac River and the flooding of the river; and to classify and describe the plant community types (associations) in the Potomac River Gorge (Great Falls Park, Virginia, and part of the C&O Canal National Historical Park, Maryland) by using the National Vegetation Classification System (NVCS) (fig. 2, page 35). The sophistication of this research is evident in the cross-sectional diagram (fig. 3, below) depicting an imaginary "slice" across the gorge. In this side view (taken from a larger, conceptual model), Mr. Lea depicts the correlation of plants growing at various elevations with the frequency that flooding inundated those areas. As he developed his conceptual model, he incorporated field data about the various vascular plant communities relative to flooding frequency and "flood energy." Concepts such as the energy of a flood (river volume and speed) were based on calculating the percentage of rock covered in "high energy" areas, and by determining the mean soil texture in "low energy" areas.

The prestige of Mr. Lea's research has already enhanced both his career and the reputation of the National Park Service. His study has been one of the few that examines fluvial environmental effects on vegetation by directly measuring flooding frequency, and one of the first to measure the effect of river energy as a factor affecting riparian vegetation. Mr. Lea has also provided vegetation classification data for several parks, and the first classification of vegetation in the Potomac River Gorge, an area well known for its nationally significant biological diversity. While classifying vegetation, he identified several community types that are currently believed to be globally rare, including *Quercus bicolor-Fraxinus pennsylvanica-Chasmanthium latifolium* woodland. His survey also revealed new locations of rare, threatened, or endangered plant species, including some that had not been found in the area for more than 70 years. These inventory results have been used in two Expedition Into The Parks research projects funded by Canon U.S.A., Inc., and included in the USGS-NPS Vegetation Mapping Program.

Other professional opportunities for Mr. Lea to share his findings have been plentiful. Individual parks in the Northeast have asked for technical assistance in classifying vegetation, and several conservation-oriented agencies and national associations have asked him to address conferences and to assist them in conservation planning. Among those interested in—and benefiting from—his research are The Nature Conservancy, the Maryland Department of Natural Resources, the Ecological Society of America, the Virginia Natural Heritage Program, and the Washington Botanical Society. In referring to the significance of these interactions, Mr. Lea observes, "The NRPDP allowed me to create professional presentations, both in the thesis (which will be further used in publishing) and at meetings. The public relations benefits and professional recognition for the National Park Service cannot be underestimated."

From a management perspective, the skills Mr. Lea developed while participating in the development program have enabled him to conduct his duties

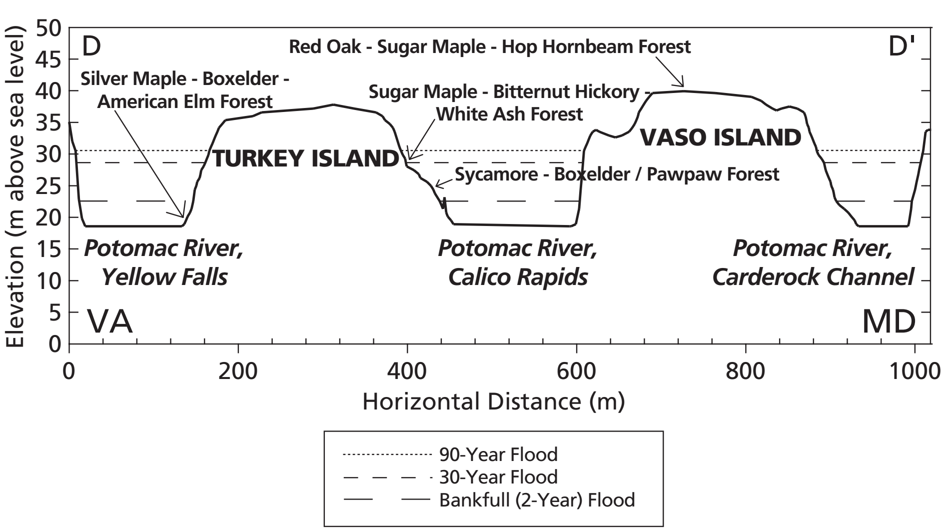

Figure 3. Taken from a larger conceptual model, this side view of the Potomac River Gorge depicts the correlation of vegetation growing at various elevations with flood frequency. Mr. Lea was able to conduct a research effort that was much more sophisticated than a typical research project at the master's level because of the support he received in the development program.

with a degree of professionalism that has made him indispensable. For example, when a threatened plant species, the seabeach amaranth *(Amaranthus pumilus)* was recently re-discovered on Assateague Island after an absence of 30 years, the park needed a comprehensive protection and restoration plan that included evaluating the species' habitat requirements and testing several restoration strategies. Carl Zimmerman, Assateague Island National Seashore's Chief of Resource Management, states that "this effort demanded strong analytic skills, the ability to research and synthesize a broad range of disparate ecological information, and a thorough understanding of research design and hypothesis testing—all of which were markedly enhanced by Chris' participation in a graduate degree program."

Acadia participant

Both Ms. Lee's and Mr. Lea's newly acquired skills have clearly benefited their respective careers and their parks. Most importantly, these participants are fulfilling the purpose of the development program by using science-based standards when they assess the condition of park natural resources and propose management strategies. A newly approved participant, Linda Gregory, also illustrates the multiple—and mutual—advantages of the program. On leave from her duties as a botanist at Acadia National Park in Bar Harbor, Maine, Ms. Gregory will receive full pay and benefits while attending graduate classes and conducting research in her park. Moreover, as part of a team examining the effect of exotic plants on the pollination of native species, she will combine the results of her graduate work in botany with the results of research by biologists with the USGS Biological Resources Division, the USGS Patuxent Wildlife Research Center, and the University of Maine.

Such a close synchronization of goals among career-minded individuals, the National Park Service, and affiliated conservation agencies is what David Manski, Chief of Resource Management at Acadia National Park, envisioned as one of the developers of the Natural Resource Professional Development Program. The equation for the program's success is aptly summarized by his observation that "Park employees earned advanced degrees before the NRPDP was established, but this program formally promotes and supports graduate study in a way that attracts and motivates employees." In effect, the Northeast Region has confirmed that designating funds and time for the development of the parks' human resources is one of the most effective strategies for meeting the Natural Resource Challenge.

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"Information Crossfile" continued from page 13

The rain-drenched mountains and valleys of the Olympic Peninsula are covered by a jungle growing on a jungle. This small, attractive, spiral-bound field guide helps people to see the jungle on top—the mosses, liverworts, and lichens. In northwest Washington lichens and mosses seem to sprout from any object moving slower than one mile per hour.

A short introductory section orients novices making their first excursion into this minute world. Topics include structure and reproduction of lichens and bryophytes, their human uses, and their important roles in the ecosystem.

The main part of the 109-page book features 101 species, with mentions of 140 more. Featured species are illustrated with a good-quality color close-up photograph, ecological notes, the elevation range of its habitats, and pointers for distinguishing similar species. The species are grouped by substrates: forest floor, logs, conifers, hardwoods, streamsides, and rock.

An accessible, inexpensive, color-illustrated book like this should open a new realm for lots of people. It should help park managers and naturalists understand and appreciate these components of biodiversity that are increasingly recognized for their indicator value and contributions to the ecosystem. This book should be sold in every bookstore, interpretive center, and gift shop on the Olympic Peninsula. Many people nearby in the Vancouver-Seattle-Portland swath will find it useful, too.

I hope this book will inspire similar efforts for other wild remnants of the continent, especially those with conspicuous mosses and lichens, such as the north country of Minnesota, the Acadian mountains and shore, the Appalachians, the swamps and sand ridges of Florida, the alpine tundra of Colorado, the forests of the northern Rockies, and of course the Alaskan mountains and tundra.

USING SURVEY RESEARCH

to analyze regional economic impacts from a change in park management

A CASE STUDY AT FORT SUMTER NATIONAL MONUMENT

By Benjamin Sigman and Naomi Kleckner

The Organic Act of 1916 charges the National Park Service with the primary responsibility of preserving park resources and values unimpaired for the enjoyment of future generations. Fulfillment of this conservation mandate requires managers to acknowledge that parks are components of larger environments, influenced by activity outside park boundaries. Park Service management policy directs park managers to address the effects of external activities on park programs, resources, and values. Furthermore, NPS policy instructs managers to consider the impact that their park management decisions will have outside park boundaries. In striving to uphold these goals of NPS policy, park managers rely on strategic planning, program coordination, scientific information, communication, and other tools. Management policy affirms that managers will use all available authorities to protect park resources and values, emphasizing the importance of understanding the complicated union between a park and its locality:

> Strategies and actions beyond park boundaries have become increasingly necessary as the National Park Service strives to fulfill its mandate.... Recognizing that parks are integral parts of larger regional environments, the Service will work cooperatively with others to ... protect park resources and values and ... address mutual interests ... such as compatible economic development and resource and environmental protection. *(Department of the Interior, National Park Service, Management Policies 2001, Section 1.5 External Threats and Opportunities)*

Survey research may be employed to augment economic input-output analysis and better understand the regional effects of management alternatives. In cases where positing the initial effects of a change in management is difficult, survey work can help park managers to better understand the implications of their decisions. For example, if managers are unsure what visitor reactions to modifications in management will be, careful survey research can provide qualitative and quantitative estimates of the change. This article describes an analysis of the new commercial services plan at Fort Sumter National Monument (hereafter, the fort) in Charleston, South Carolina. It is a strong case study in the use of survey research to assess regional economic effects attributable to complicated management changes with direct effects on area attractions.

"Survey research may be employed to augment economic input-output analysis and better understand the regional effects of management alternatives."

Case study: Fort Sumter National Monument

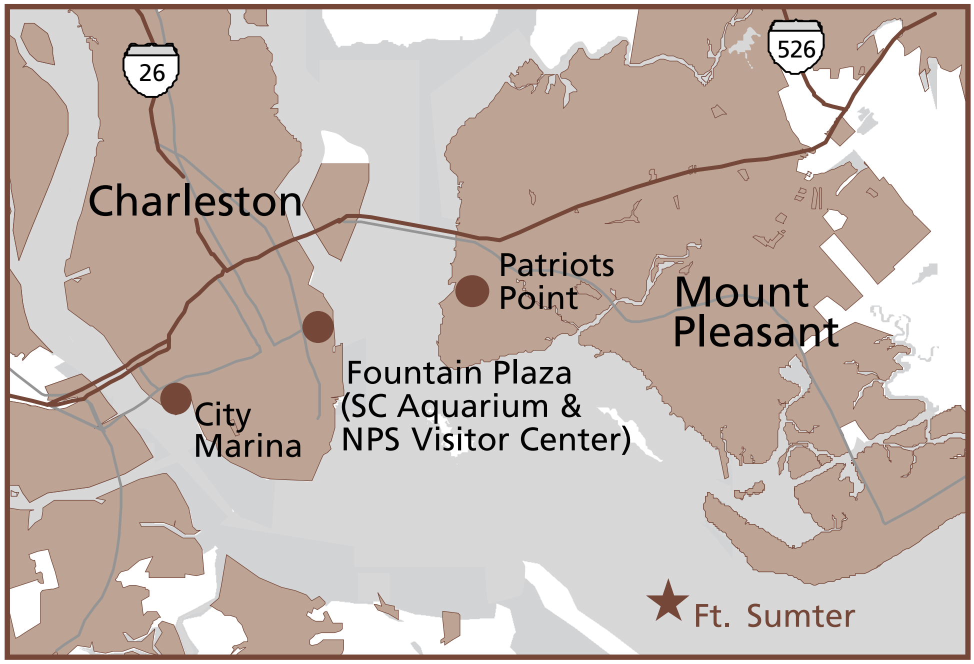

Figure 1. Map showing location of new and former departure points and visitor services facilities for Fort Sumter National Monument, South Carolina.

For over 40 years, the National Park Service has sought a facility in historic Charleston that would provide permanent tour boat access to Fort Sumter National Monument. Under the previous commercial services plan, a concessioner provided access to Fort Sumter from two departure points, the City Marina in Charleston and Patriots Point in Mount Pleasant (fig. 1). The National Park Service had no control of the lease, operation, or management of the tour embarkation points used by the Fort Sumter concessioner. The Charleston peninsula tour boat facility at the City Marina on the Ashley River was inadequate, even on average use days. Parking was limited; the site lacked an NPS visitor contact station, NPS presence, and rest rooms. A second tour boat dock provided in 1985 at Patriots Point in Mount Pleasant had adequate parking and rest rooms but did not have a visitor facility with NPS interpretative services. Additionally, both locations lacked adequate handicapped access. (Fort Sumter tour boat facility webpage, http://www.nps.gov/fosu/dockside/index.htm.)

After two failed attempts to develop a suitable dock site and visitor center in historic Charleston in the late 1970s and early 1980s, the National Park Service entered into an agreement to develop a site on the eastern side of the Charleston peninsula. In 1986, the Park Service purchased this riverside site, and the master plan was amended with a cooperative proposal for the National Park Service to co-develop this site. The Fort Sumter project was viewed as a perfect match with the City of Charleston, which was seeking a site for a state aquarium. This site offered enough space for the integration of the NPS facility and the envisioned South Carolina Aquarium, an IMAX theater, and a restaurant. In addition, a parking garage was constructed across from the NPS site. Fountain Plaza (i.e., South Carolina Aquarium and IMAX theater) and the parking garage opened in 1999. The NPS facility opened to the public in August 2001 (fig. 2), and a formal opening and dedication was held in November. In addition to a museum, which is free to the public, the new facility provides docking space for the concessioner ferries that facilitates access to the fort; offers shade shelters, landscaped areas, and rest rooms; and creates a significant NPS presence in Charleston.

The opening of the NPS facility and its boat launch called for a new commercial services plan. Under the new plan, the National Park Service would consolidate the ferry operations providing transport to the fort. The new boat dock on the Charleston peninsula would become the sole departure point from which the public would access the fort.

Figure 2. The new Fort Sumter visitor center and boat dock began public operation in August 2001.

Concerns surrounding the management change

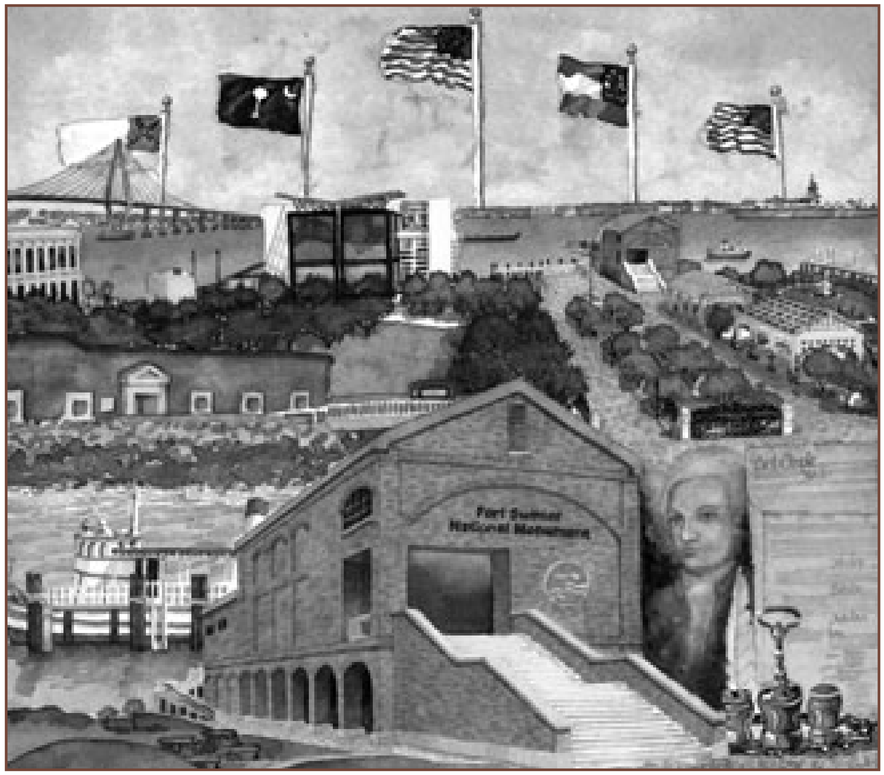

ILLUSTRATION BY PHILIP THYS, DSC, NPS

From November 1999 to January 2000, Fort Sumter National Monument made its commercial services plan available for public comment. Several interested parties raised concerns, including the Patriots Point Development Authority (the Authority). The Authority believed that discontinuing the departure point at Patriots Point would negatively affect the town of Mount Pleasant, Patriots Point Naval and Maritime Museum, and the national monument.

In response to comments received from the Authority and other stakeholders, Fort Sumter Superintendent John Tucker commissioned a study assessing the potential regional economic impacts of the new management plan. Specifically, Superintendent Tucker intended to estimate the impact on the Mount Pleasant economy from changing Fort Sumter's departure points; the financial impact on Patriots Point Naval and Maritime Museum; and estimate the change in fort visitation. In addition, Superintendent Tucker hoped to learn whether fort visitors would take advantage of a proposed water taxi service from Mount Pleasant to downtown Charleston and whether fort visitors would benefit from the option to spend more time at the fort.

The analysis

Assessing the potential impacts of the change in Fort Sumter commercial services faced several analytic challenges. First, limited information existed to assess the relationship between fort visitation and visitation at Patriots Point and the South Carolina Aquarium. Originally, both the National Park Service and Patriots Point saw mutual benefits to the Fort Sumter departure point at Patriots Point. The two attractions have similar appeal to a subset of Charleston area visitors, and Patriots Point had space capable of accommodating a limited docking facility. The Patriots Point Naval and Maritime Museum, like Fort Sumter National Monument, is focused on American military history, offering tours of a World War II aircraft carrier, destroyer, and other exhibits. It was assumed that visitors planned to visit both the fort and Patriots Point on the same trip or that sharing a site generated incidental visits among visitors planning to see only one of the two attractions. These assumptions were supported by visitation data that showed similar trends over time for both attractions. The National Park Service was not sure to what degree Patriots Point would be affected by the management change and whether this type of relationship might be created between the fort and the South Carolina Aquarium.

Furthermore, limited information was available to characterize how fort visitors, especially those departing from Patriots Point, contributed to the economic trends of the Charleston area. Mount Pleasant had seen strong economic growth and development in tourist services, especially overnight accommodations, in recent years. Without primary research, the National Park Service was uncertain of the extent to which the Fort Sumter boat launch at Patriots Point had helped support tourism growth in Mount Pleasant. Also unclear was the extent to which fort visitors would alter their selection and use of tourist services (e.g., location of lodgings) in response to offering a departure point only from the City of Charleston.

To complete this assignment, we developed three distinct surveys and administered them to fort visitors, Charleston area visitors, and Charleston area residents using a self-administered intercept approach (i.e., respondents complete questionnaires on-site).[1] The effort to survey Fort Sumter visitors took place on the boats returning from the fort, while Charleston area visitors and residents were interviewed outside of the recently opened aquarium. Collectively, the survey results established a profile of Fort Sumter's role in the region's tourism and economy, defined the existing

[1] The survey effort was exempt from Office of Management and Budget survey instrument review due to the litigant nature of the research.

patterns in visitation, and projected the potential changes due to the Fort Sumter visitor center opening.

The survey of Fort Sumter visitors asked respondents about the details of their Charleston visit. The first section of the survey gathered information on reasons for visiting the area and how a fort visit fit into their plans for the day and overall Charleston area visit. The second section addressed satisfaction with the fort experience, followed by a section that gave respondents the opportunity to choose between two carefully developed management alternatives (table 1). With each alternative, respondents considered attributes of the fort experience, such as the value of park ranger presence, interpretive displays, admission to exhibits, seating while waiting for the tour boat, parking, boat departure times, and departure location. The choice required respondents to collectively consider the trade-offs among eight attributes pertaining to the two management alternatives. The survey also asked which factors were the most important in making their decision. Finally, the survey asked visitors about the logistics of their visit, focusing on party size, length of stay, lodging location, important attributes of accommodations (e.g., location, price, amenities), as well as demographic and socioeconomic information.

Charleston area visitors and residents interviewed at the South Carolina Aquarium answered similar questions about the details of their visit to the aquarium, activities planned for the day (and for area visitors, overall plans for their trip to Charleston). The surveys asked respondents about their familiarity and interest in Fort Sumter National Monument (e.g., plans to visit the fort), interest in the new visitor center, and how they might have combined their visit to the aquarium with a visit to the fort under the future commercial services plan. Area visitors also answered the same set of questions about their trip logistics (e.g., lodging questions); both area visitors and residents answered the demographic and socioeconomic questions.

The three surveys were carefully developed with input from Superintendent Tucker and several peer-reviewers and then pre-tested. The administration of surveys to fort visitors took place over three days in June 2000, resulting in approximately 580 collected surveys. One month later, a two-day survey took place at the aquarium, with nearly 500 surveys collected. The scientific approach to survey design provided reliable data defining baseline trends in Fort Sumter visitation, future trends in Fort Sumter visitation, and the regional economic impacts associated with a change in management practice.

"No evidence suggested that Charleston area visitors will alter their use of tourism services based upon Fort Sumter's new departure site."

Findings

The data suggested minimal impacts on the Mount Pleasant economy as a result of consolidating the two departure points. The analysis used questions about lodging choice (i.e., lodging attributes such as cost,

Table 1. Potential management options for Fort Sumter from the survey of Fort Sumter visitors.
"[Below] are two options for boat departure points to Fort Sumter, Option A and Option B. The differences between the two options are described for each. Considering all of these factors which option do you prefer?"

		Option A	Option B
A	Amount of time spent at the Fort.	Stay at the fort for one hour.	Option to stay at the fort longer than one hour.
B	Park rangers available to answer questions and give historical talks.	Available only at the fort.	Available while waiting for the boat, on the boat, and at the fort.
C	Displays and exhibits about Fort Sumter while waiting for the boat.	At Patriots Point: displays about Civil War on outside building wall. City Marina: no exhibits.	National park museum about Fort Sumter at departure site. Also, displays in nearby park along walkways.
D	Admission to the exhibits.	At Patriots Point: free admission to displays. City Marina: no exhibits.	Free admission to museum.
E	Seating while waiting for the boat.	At Patriots Point: seating in shaded open air food service area. City Marina: no sheltered area.	Seating in air conditioned museum and shaded outside seating.
F	Parking near the departure point.	Free parking in a lot at Patriots Point. Street parking near the City Marina.	Paid parking in garages across the street from the departure point.
G	Number of times per day that a boat leaves for the fort.	3 times per day (one boat every 2 1/2 hours) from each departure point.	On average 6 times per day (about one every hour).
H	Fort Sumter departure point location(s).	Two departure points-Patriots Point (in Mount Pleasant) and the City Marina (in Charleston).	One departure point-beside the South Carolina Aquarium in Charleston.

location, and proximity to attractions) as an indicator of how area visitors might change their use of services supporting area tourism and, consequently, of the magnitude of regional economic effects. Responses to these questions showed no statistical difference in the lodging choice of Fort Sumter visitors and aquarium visitors (who did not plan to visit the fort). Lodging choice was driven by the cost of the room and the ease of getting to a *variety* of attractions in the Charleston area. Consequently, no evidence suggested that Charleston area visitors would alter their use of tourism services based upon Fort Sumter's new departure site. The town of Mount Pleasant should experience little, if any, change in hotel revenues (and hotel spin-off revenues) due to the new Fort Sumter departure site.

The survey research did confirm that the Patriots Point Naval and Maritime Museum will experience some loss in gross revenues on account of the new commercial services plan. Research indicated that Patriots Point may see a reduction between two and twelve percent of its annual gross revenues as a result of the change in the Fort Sumter departure point to downtown Charleston. The upper bound of the estimated change in total revenues is roughly equal to what the Authority had presented as a lower-bound estimate of lost revenue in their position paper.

> "Patriots Point may see a reduction ... of its annual gross revenues as a result of the change in the Fort Sumter departure point to downtown Charleston."

An important finding of the survey research was that the new visitor center would significantly increase fort visitation. The new visitor center increases the exposure of Fort Sumter National Monument to Charleston area visitors, resulting in a significant increase in visitation. This gain in visitation will more than offset the loss in visitors who preferred the former departure options. Specifically, we estimate that consolidation of Fort Sumter departure points will lead to a net increase in Fort visitation of 16,000 to 25,000 visits per year (recently the fort has supported approximately 240,000 visits annually). We also estimate that the national monument will serve approximately 29,000 additional visitors per year who are interested in seeing the visitor center but do not have the time to visit the fort.

Additionally, the survey revealed information regarding visitor preferences. For example, the research determined that one-third of visitors to Fort Sumter want to spend more time at the fort. Such information supports the management change and informs future boat scheduling options. The survey also investigated the feasibility of a water taxi, running between Mt. Pleasant and downtown Charleston. Approximately one-third of fort and aquarium visitors, stated they would "definitely" or "most likely" use a taxi service. These results suggested that Patriots Point's revenue loss could be significantly offset by offering a commercial water taxi service between Patriots Point and Fountain Plaza. The tourist traffic using a water taxi would also increase Patriots Point's visibility to Charleston area visitors who did not plan on visiting it.

Finally, survey research provided useful and specific information on the visitors themselves. A strong understanding of Fort Sumter visitor gender, race, age, educational attainment, employment, income, and home residence was obtained. This information will help Fort Sumter managers to make educated decisions on issues affecting the entire visiting population.

Conclusion

The regional economic analysis of a change in management at Fort Sumter National Monument proved to be a successful exercise in using survey research to gain information important to park management. A significant amount of information on visitation, future trends in visitation, and the regional economic impacts associated with the change in management practice was collected. This analysis was an essential first step in understanding how Charleston area visitors and residents would react to management change at Fort Sumter. Without the information provided by this survey effort, the ramifications of the change in management could not have been quantified before the implementation of the new commercial services plan. In addition, the completion of the analysis cleared the path for further analyses that may include input-output modeling or an examination of the changes in social welfare associated with the consolidation of departure points at Fort Sumter National Monument.

In the future, an analysis of visitation data collected after the implementation of the new commercial services plan will allow for verification of the survey's accuracy. Tracking visitation trends under the new commercial services plan will allow researchers to compare visitors' actual behavior to their stated responses to management changes. Examination of the projected effects versus actual effects will allow for methods used in this survey effort to be further refined for future use.

About the Author

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Hindsight makes better foresight: PALEONTOLOGY AS A NEW TOOL FOR CONSERVATION

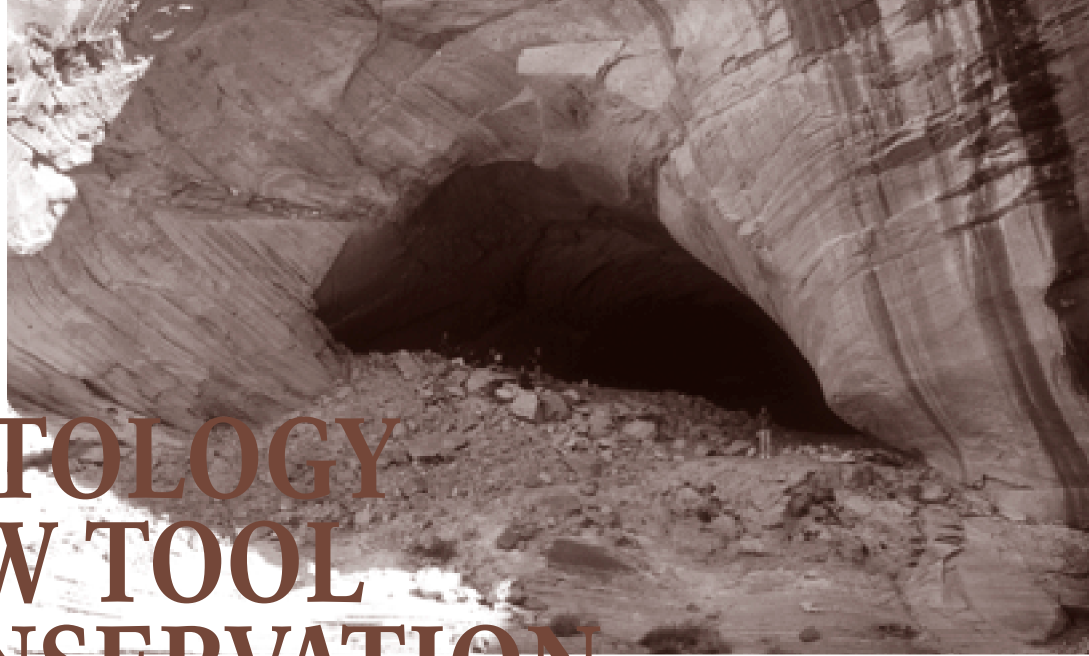

Figure 1. Caves like this one at Glen Canyon National Recreation Area often preserve fossils of plants and animals that lived during the Pleistocene (Ice Age). Fossil surveys at sites like this help document the response of various species to environmental change.

By Dan Chure, Ph.D.

"In this chapter, we consider what ought to be paleontology's most vital calling: use of the vast record of life's prehistory to help understand and conserve its threatened descendants."

—Archer, Hand, and Godthelp

DINOSAURS! DINOSAURS!! DINOSAURS!!!

TV, movies, and popular books could easily lead one to believe that those huge, brooding, bad-tempered reptiles were the only life of the past. Although one can go broke subscribing to the Dinosaur Book-of-the-Week Club, there are some other popular books that focus on the many other wonderful creatures that have populated our planet over the past millennia. These non-dinosaur books introduce us to past life otherwise still buried in the pages of scientific journals.

The recently published book *Australia's Lost World: Prehistoric Animals of Riversleigh* by Mike Archer, Suzanne Hand, and Henk Godthelp (2000) adds to the limited list of non-dinosaur works. This book describes the Riversleigh fossil beds in northwestern Queensland, among the richest and most extensive in the world. Their significance was formally recognized by the Australian government when the fossil beds were incorporated into Lawn Hill National Park in 1992 and when UNESCO designated them a World Heritage Site in 1994. Among its important values, this fossil treasure provides a record of how Australia's ancient rainforests were transformed into a largely arid landscape in response to climate change over the last 15 million years.

PALEONTOLOGY AND CONSERVATION EFFORTS

However, *Australia's Lost World* is more than just a book about spectacular fossils. It is also about conservation biology and how paleontology can provide critical information for developing strategies for conserving our living biota. The authors make a strong case that the conservation status of living species can not be determined solely on information gathered over a few decades of modern field studies. As the authors write, (p.9) "Rarity can not be interpreted as anything other than rarity. To tell if a lineage is in the process of decline, stability, or rise, we must have an historical perspective—and not just that of the last few centuries." And for that reason this book should be of interest to the readers of *Park Science*.

"*Australia's Lost World* ... is also ... about conservation biology and how paleontology can provide critical information for developing strategies for conserving our living biota."

"Conservation status of living species can not be determined solely on information gathered over a few decades of modern field studies."

The book provides several examples of how paleontology can be important for conservation issues. One of the more interesting ones involves the recent "plagues" of the crown-of-thorns starfish *(Acanthaster planci)* on Australia's Great Barrier Reef. The recent blooms of this reef-eating starfish have been attributed to human interference, such as the over-collection of *Triton* snails, an important predator of this starfish. As a result, aggressive control programs were implemented to reduce the populations of *A. planci*, including having divers inject starfish with heavy metal solutions. However, this strategy was called into question when the fossil record of this starfish was more closely examined. Walbran et al. (1989) cored the Great Barrier Reef for just that data and found evidence for episodic blooms of this starfish going back more than 4,000 years, well before Europeans came to Australia. This has raised serious doubt as to whether or not these "plagues" are human induced. It also raised the intriguing question as to whether or not humans may have disrupted what may well be a normal, if cyclic, process, and that disruption might actually have had a detrimental effect on the very reef systems those actions were designed to protect. Might not these starfish population explosions be the marine equivalent of a forest fire?

In some cases, paleontology can help identify both positive and negative impacts of what the authors call the "heavy hand of humanity." Using the Late Quaternary record of fossil vertebrate accumulations in caves, Alex Baynes (1990) determined that small to medium-sized Australian mammals show remarkable stability throughout the record preserved in caves. Changes in distribution patterns since the arrival of Europeans are many times greater than over the last 10,000 years. Here we can see that recent human activities have had a detrimental impact on species.

Flannery (1990), on the other hand, argues that the loss of many medium-sized arid and semi-arid Australian mammals is likely the result of a secondary chain of extinctions (a "trophic cascade") following the great extinction of Australia's megafauna some 20,000-40,000 years ago. That this cascade did not immediately follow the megafaunal extinction event is likely due to the Aboriginal use of fire, which maintained complex vegetation systems and thus delayed the trophic cascade. With the arrival of Europeans, and the subsequent loss of Aboriginal land management practices, extinctions accelerated to Late Pleistocene levels. One conclusion Flannery draws is that maintaining Aboriginal fire practices may well be important in preventing further extinctions.

IMPORTANCE OF THE PLEISTOCENE AND QUATERNARY RECORD

Australia's Lost World makes it clear that the Pleistocene and Quaternary fossil record of Australia has important information that needs to be incorporated into conservation plans for species and ecosystems. In fact, ecologists are now working as co-investigators on the Riversleigh projects because of their recognition of the potential for establishing long-term trends in Australian ecosystems.

The Pleistocene and Quaternary fossil record also contains valuable information for the United States (fig. 1, page 43). An understanding of this history is fundamental to the preservation of our current biota. Over the last 19,000 years in North America we have gone from the maximum southern spread of continental ice sheets to the present reduced glacier distribution. During this same time period the ecosystems shifted in

Figure 2. Discovered in Grand Canyon National Park, Arizona, this fossilized condor skull is evidence that the large, scavenging bird once lived in the area. This information was important in considering reintroduction of the species in the past decade. COPYRIGHT STEVE EMSLIE

response to the retreat of the ice sheet, the arrival of the first humans in North America, and a continent-wide megafaunal extinction. These tremendous changes are the crucible in which our modern biota was forged. Quaternary geologists and paleontologists have amassed a phenomenal amount of data for this time interval. Correlation of physical events, flora, and the fauna over the last 50,000 years of prehistory can be excellent, thanks to refined C^{14} dating techniques, which can yield dates with errors of only ±50 years! Thus, fine-scale calibration of events and species distributions is possible. And while getting genetic material out of dinosaur bones is something best left to the movies, the wizards of molecular biology have successfully extracted DNA from more recent fossil bone. This allows us to trace the stability of or changes in population genetics, sometimes in still living species, over tens of thousands of years.

The fossil record also often includes species that are either still alive or are the immediate ancestors of living species (fig. 2). Even DNA is preserved! Here we have the record of very recent extinction and evolution, biotic crisis and biotic response. This is critical data for understanding how the present came to be and where it may head in the future. To ignore this record is unwise.

"There has been little interdisciplinary overlap between Quaternary earth scientists and the modern conservation and restoration communities."

Surprisingly, in spite of all this branch of paleontology has to offer, there has been a lack of communication between Quaternary earth scientists and the modern conservation and restoration communities. There is, however, some recent work that shows just how valuable such collaboration can be. Cooper et al. (1996) have used fossil distribution and fossil DNA data for the Laysan duck *(Anas laysanensis)* to show that in the past this species occurred on more islands than at present and that the fossil populations were genetically quite similar to extant populations. This information can be used to identify islands and areas where the reintroduction of the Laysan duck may be most successful.

The research of Wayne et al. (2000) is another example of how paleontological information can help conservation efforts. Studying the mitochondrial DNA of brown bears *(Ursus arctos)* preserved in the permafrost, these scientists have been unraveling the complex pattern of population genetics changes in this carnivore. Some 36,000 years ago the brown bear was much more diverse genetically, but by 15,000 years ago the level of genetic diversity had dropped to that of modern populations. The details of this work suggest that relying solely on the genetic diversity data of living brown bear populations could lead to erroneous conservation management decisions.

NEW ROLES FOR THE NPS IN PALEONTOLOGY?

What does all this mean for the National Park Service and the preservation of our living treasures? The Service has an extensive Inventory and Monitoring Program (I&M) under way—one that is monitoring both the living and nonliving components of our ecosystems. A predetermined core of basic data themes is being gathered nationwide, while more specialized inventories, such as paleontology, are left to the responsibility of individual parks. Now I have heard some lamentations about fossils not being included in the I&M Program. In my view as a research paleontologist, fossils are generally not directly relevant to the problem the I&M Program is addressing—systematically gathering standardized information to establish a statement of the condition of the present-day ecosystems in relation to their unimpaired state. In particular, although we have learned much about dinosaurs from fossils, it is difficult to apply that knowledge directly to the problems of our present-day biota.

> **"Our fossil resources need to be inventoried, monitored, studied, and protected because of our mission and their scientific and educational value...."**

But do not get me wrong. Fossils—even those that are not dinosaurs—are extremely important. They are, after all, the record of the history of life on our planet. Many national parks with fossils are international benchmarks for particular times in the past. Literally thousands of scientific papers have been published on fossils of the National Park System units and the list is continually growing. Our fossil resources need to be inventoried, monitored, studied, and protected because of our mission and their scientific and educational value, regardless of what they may or may not tell us about the future. Let us hope that the monies available through the Natural Resource Challenge for resource inventories will free up other sources (such as the Natural Resource Preservation Program) to fund systematic fossil inventories. Another possibility would be to develop Servicewide funding for paleontological inventories through the Natural Resource Program Center, where such inventories could be prioritized by resource and management needs.

It seems unlikely that the current NPS I&M Program can fund fossil surveys—even those with an emphasis on the Quaternary record. However, that should not prevent us from exploring how Pleistocene and Quaternary earth scientists might work with us to understand the time aspect of the resources we care for. Knudson (1999) and McDonald and Chure (2001) have recently made a similar plea. This cooperation will require partnerships with other land management agencies as well—the canvas on which the recent fossil history of North America is painted is larger than the lands administered by the National Park Service. Maybe the Service, as the nation's leading conservation agency, can help bring the paleontological and conservation professionals together. To do so may well reap great rewards.

> **"Maybe the Service ... can help bring the paleontological and conservation professionals together."**

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Meetings of Interest*

June 2–5

Indiana University, Bloomington, is the venue for the Ninth International Symposium on Society and Resource Management, titled "Choices and Consequences: Natural Resources and Societal Decision Making." This symposium centers on the contributions of the social sciences to a better understanding of resource management issues. A major premise is that complex natural resource issues are societal problems and must be addressed through an interdisciplinary social science perspective that includes decision making within multidimensional social and cultural frameworks. Dialogue and interaction among natural resource managers, social scientists, policy makers, and the public is anticipated. Themes include: identification, management, and resolution of natural resource conflict; models, measurement, and public participation in capacity management; emerging natural resource issues management; and integrating natural resource management in a context of public norms, expectations, and managerial systems. Further information can be found on the Web: www.indiana.edu/~issrm/.

June 2–7

The Society of Wetland Scientists is hosting its 23rd annual meeting in Lake Placid, New York, focused on "Wetland Linkages: A Watershed Approach." Scientific dialogue will explore how wetlands are being integrated into watershed management initiatives and how they are linked to issues about economics, ecology, and energy. A technical program will examine wetland issues making news today. Visit www.sws.org/lakeplacid/ for further information.

August 4–9

The Ecological Society of America (ESA) and the Society for Ecological Restoration (SER) will be meeting jointly in Tucson, Arizona. The theme of the meeting is "A Convocation: Understanding and Restoring Ecosystems." The organizers are calling this conference a convocation because it is the coming together of two organizations, ESA and SER, that share the common purpose of using basic ecological knowledge to solve practical environmental problems. The meeting will include practitioners, managers, regulators, academic scientists, agency researchers, educators, and interested citizens. The organizers also are encouraging ecologists and restorationists in Mexico and Latin America to attend. Esteemed Harvard biologist E. O. Wilson will be giving the keynote address to the conference. For further information on the conference, consult www.esa.org/tucson, or contact the program chair: Paul H. Zedler, Institute for Environmental Studies and Arboretum, University of Wisconsin–Madison (608-265-8018; esa@mail.ies.wisc.edu).

September 30–October 2

The symposium "Innovations in Species Conservation: Integrative Approaches to Address Rarity and Risk" will convene in Portland at the Oregon Convention Center. Focusing on the conservation of rare and poorly known species, invited speakers and audience participants will discuss the ecological, social, and legal contexts for various conservation strategies and the risks and uncertainties associated with each species. Target audiences include public and private resource managers, scientists, policy makers, conservation organizations, and the public. The symposium is sponsored by the USDA Forest Service, U.S. Geological Survey, U.S. Fish and Wildlife Service, Bureau of Land Management, Oregon State University, Society for Conservation Biology, The Nature Conservancy, and others. The registration fee is $150. More information is available at http://outreach.cof.orst.edu/species/.

October 2-5

The 29th annual conference of the Natural Areas Association will take place in Asheville, North Carolina, exploring the "Power of Nature and the Empowerment of Natural Areas." Participants will be challenged by new information and new ways of thinking about the conservation and management of natural areas. Organizers hope to raise awareness and optimism among attendees who can make a difference in the conservation of natural lands and biodiversity. Several session tracks revolve around the concept of adaptive management and include: adaptive management and climate change, adaptive management in fire-dependent communities, prioritizing invasive species management in an adaptive context, and hydrologic alteration and adaptive management. Additional information is available at www.natareas.org.

*Readers with access to the NPS Natural Resources Intranet can view a comprehensive listing of upcoming meetings, conferences, and training courses at www1.nrintra.nps.gov/NRMeet/.

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